

Chapter 2 Notes

2-1: Early Chemical Discoveries and the Atomic Theory

- Law of conservation of mass- the total mass of substances present after a chemical reaction is the same as the total mass of substances before the reaction (matter is neither created nor destroyed in a chemical reaction)
- Law of constant composition (definite proportions)- all samples of a compound have the same composition- the same proportions by mass of the constituent elements
- Dalton's atomic theory:
 - Each element is composed of minute, invisible particles called atoms; atoms can neither be separated nor destroyed during a chemical change
 - All atoms of an element are alike in mass and other properties, but the atoms of one element are different from those of all other elements
 - In each of their compounds, different elements combine in a simple numerical ratio
- Law of multiple proportions- if two elements form more than a single compound, the masses of one element combined with a fixed mass of the second are in the ratio of small whole numbers
- Atomic weights- the characteristic masses of the atoms of the various elements

2-2: Electrons and Other Discoveries in Atomic Physics

- Positives and negatives attract; two positives or two negatives repel each other
- Rubbing can separate some positive and negative charges
- Discovery of Electrons:
 - Cathode rays- negatively charged particles (electrons) emitted at the negative electrode (cathode) in the passage of electricity through gasses at very low pressures
 - Cathode rays travel in straight lines
 - Deflected by electric and magnetic fields in the manner expected for negatively charged particles
 - Cathode rays became known as electrons
 - Electrons- particles carrying the fundamental unit of negative electric charge; found outside the nuclei of all atoms
 - Robert Millikan determined electric charge through oil drop experiments
 - Electronic charge is $-1.6022 \times 10^{-19} \text{ C}$
 - Mass of electron is $9.1094 \times 10^{-28} \text{ g}$
 - J.J. Thompson- positive charge necessary to counter balance negative electrons in a neutral atom was in form of nebulous cloud; electrons floated in a diffuse cloud of positive charge (plum pudding model)
- X-Rays and Radioactivity:
 - Wilhelm Roentgen noticed that when cathode ray tubes were operating, materials outside the tubes glowed; caused by radiation emitted by cathode ray tubes; called them x-rays

- Antoine Henri Becquerel discovered radioactivity (the phenomenon in which small particles of matter or electromagnetic radiation are emitted by unstable atomic nuclei)
- Types of radiation from radioactive materials:
 - Alpha particles (α)- carry two fundamental units of positive charge and have essentially the same mass as helium atoms
 - Beta particles (β)- negatively charged particles produced by changes occurring within the nuclei of radioactive atoms and have the same properties of electrons
 - Gamma rays (γ)- not made up of particles; it is electromagnetic radiation of extremely high penetrating power
- Chemical properties of a radioactive element change as it undergoes radioactive decay
- Radioactivity involves fundamental changes at the subatomic level; in radioactive decay, one element is changed into another (transmutation)

2-3: The Nuclear Atom

- Rutherford began a line of research using alpha particles as probes to study inner structure of atoms
- Metal foil experiment: telescope traveled in a circular track around evacuated chamber containing metal foil and bombarded thin foils of gold
 - The majority of alpha particles penetrated the foil undeflected
 - Some alpha particles experienced slight deflections
 - A few (1 in every 20,000) suffered rather serious deflections as they penetrated the foil
 - A similar number did not pass through the foil at all, but bounced back in the direction from which they had come
- Explained by nuclear atom model:
 - Most of the mass and all of positive charge of an atom are centered in a very small region called the nucleus; the remainder of the atom is mostly empty space
 - The magnitude of the positive charge is different for different atoms and is approximately one half the atomic weight of the element
 - There are as many electrons outside the nucleus as there are units of positive charge on the nucleus; the atom as a whole is electrically neutral
- Protons- fundamental particles carrying the basic unit of positive electric charge and found in the nuclei of all atoms
- Neutrons- electrically neutral fundamental particles of matter found in all atomic nuclei except the hydrogen atom, protium, ^1H
- Atomic number (proton number) (Z)- number of protons in a given atom; also number of electrons outside the nucleus of an electrically neutral atom
- Mass number (A)- the total number of protons and neutrons
- Neutron number ($A-Z$)- the number of neutrons
- Atomic mass unit (amu)- 1/12 of the mass of the atom known as carbon-12

2-4: Chemical Elements

- All atoms of a particular element have the same atomic number (Z); all atoms with the same number of protons are atoms of the same element
- Chemical symbols- abbreviations of the names of the elements (ex: Ne=neon)
- Isotopes- atoms that have the same atomic number (Z) but different mass numbers (A)
- Percent natural abundances- the relative proportions, expressed as percentages by number, in which the isotope of an element are found in natural sources
- Ions- formed when atoms lose or gain electrons; carry net charges
- Adding electrons produces a negatively charged ion; taking away electrons forms a positively charged ion
- Number of protons does not change
- Can't add up masses of fundamental particles to find mass of an atom; small portion of original mass is converted to energy and released
- Mass spectrometer- device used to separate and to measure the quantities and masses of different ions in a beam of positively charged gaseous ions

2-5: Atomic Mass

- Atomic mass (weight)- average of isotopic masses weighted according to the naturally occurring abundances of the isotopes of the element and relative to the value of exactly 12 u for a carbon-12 atom

2-6: Introduction to the Periodic Table

- Periodic table- an arrangement of the elements, by atomic number, in which elements with similar physical and chemical properties are grouped together in vertical columns
- Families (groups)- vertical columns on periodic table
- Atomic number is above symbol; atomic mass is below symbol
- Divided into 2 categories:
 - Metals- elements whose atoms have small numbers of electrons in the outermost electronic shell; lustrous appearance; malleable and ductile; able to conduct heat and electricity
 - Nonmetals- an element whose atoms tend to gain small numbers of electrons to form negative ions (anions) with the electron configuration of a noble gas; can also share electrons; mostly gases, liquids, or low melting point solids; very poor conductors of heat and electricity
 - Noble gases- elements whose atoms have the electron configuration ns^2np^6 in the electronic shell of highest principal quantum number
 - Metalloids- elements that may display both metallic and nonmetallic properties
- Periods- horizontal rows
- Lanthanides- period of 15 elements at bottom of periodic table; begins with lanthanum (Z=57)
- Actinides- period of 15 elements at bottom of periodic table; below lanthanides
- Main-group elements- those in groups 1, 2, 13, and 18
- Transition elements (transition metals)- elements in groups 3 to 12; all metals