Falling Apple Science Chemistry Outline

Introduction

- The “magic” of chemistry
  - Chemical vs. physical changes
- Early applications
  - Fire (light, heat, protection, cooking, and pottery)
    - How to make hotter fires (charcoal, hearths)
  - Metals: copper and bronze, iron and steel
  - Glass, alcohol, soap, and dyes for clothes
  - Explosives (gunpowder, Greek fire)
- Technological applications in the modern world

Chapter 1: Sulfur and Metal Sulfides

- Pure sulfur in nature (alpha and beta)
- Copper sulfide (chalcopyrite)
- Iron sulfide (pyrite)
- Lead sulfide (galenite)
- Mercury sulfide (cinnabar)
- Zinc sulfide (sphalerite)
- [Include color pictures of the ores and identify the major mining locations. Discuss how the metal can be separated from the sulfur (analysis) and how the metal can be combined with the sulfur to make the ore (synthesis). Discuss the practical uses of the materials.]

Chapter 2: Carbon

- Where it is found, and it’s various forms and uses
- Carbon sulfide

Chapter 3: Air and Metal

The rusting of lead, mercury, and copper

Air as a mixture of oxygen and nitrogen

Mixtures vs. substances

Compounds vs. elements

Chapter 4: Metal Oxides and Alloys

Iron, tin, titanium, and aluminum (electrolysis required to get Al)

Laws of definite and multiple proportions

Bronze and steel

Zinc, brass and stainless steel

Magnesium (electrolysis from brine)

- Burns in oxygen with bright white light
- Useful alloys with aluminum and iron

Native metals: gold, silver, and platinum

Chapter 5: Water

Water as a compound of oxygen and hydrogen

Properties of water

Hydrogen peroxide

Chapter 6: Gases

Basic law of gases (Charles Law)

Some common gaseous compounds: SO_2, H_2S, CO_2, CO, CH_4, C_2H_6, C_2H_4, N_2O, NO, NO_2, NH_3 (but don't use formulas yet)

Law of combining volumes

Avogadro's law (mention the discovery of ozone)

Atomic weights

Chemical formulas

Chapter 7: The Kinetic Theory of Gases

Atomic explanation for the laws of Charles and Avogadro

The laws of gaseous diffusion, heat conduction, and viscosity

Chapter 8: The Give and Take of Heat

The Dulong-Petit law

Phase transitions, latent heat

Exothermic and endothermic chemical reactions

Chapter 9: Sodium and Chlorine

Table salt: NaCl

Separating the elements by electrolysis (lye: NaOH)

Faraday's law of electrolysis

Sodium carbonate and sodium cyanide

Hydrogen chloride, metal chlorides, and carbon chlorides

Potassium and fluorine

Chapter 10: Acids Containing Oxygen and Their Salts

Sulfuric acid and the important sulfates (introduce calcium here)

The electromotive series of the metals

Nitric acid and the important nitrates

Phosphoric acid and the important phosphates

Chapter 11: Silicon and Its Compounds

SiO_2, Na_2SiO_3, $CaSiO_3$: sand and glass

Pure Si and its uses

SiC

Rocks and minerals (overview)

$Al_2Si_2O_7$ (clay), $KAlSi_3O_8$ (feldspar), $K_2Al_2(AlSi_3O_{10}):2H_2O$ (mica)

$(Mg, Fe)_2SiO_4$ (olivine), $Mg_3Si_4O_{10}(OH)_2$ (talc)

[Note: More than 99% of the Earth's crust consists of only the dozen elements O, Si, Al, Fe, Ca, Mg, Na, K, H, Ti, C, and Cl – in an amazing variety of combinations.]

Chapter 12: Valence and the Periodic Table

Valence: Start with hydrogen and chlorine compounds

Show how the valence is determined for the two dozen elements we have thus far studied in this course

Elements with the same valence have similar chemical properties

Natural pairings, for example: Na and K, Mg and Ca, C and Si, N and P, O and S, F and Cl

Atomic weights: How the ambiguities are resolved with the help of valence and the Dulong-Petit law

Determine the rest of the atomic weights of elements studied

The Periodic Law

Some rare elements that are similar to those already studied

The inert gases

The periodic table

Chapter 13: Molecular and Atomic Structure

Molecules

Isomers

The case of benzene and its derivatives

The tetrahedral structure of carbon bonds

Early examples of molecular structure determination

Atoms

Discovery of the electron

Discovery of the nucleus

Revisiting the periodic table: chemical properties as determined by "outer electrons"

Modern instrument analysis

Spectroscopy

Chromatography

X-ray diffraction crystallography

Chapter 14: Carbon Compounds in Life and Industry

Industry

Plastics (start with units such as ethylene and benzene)

Fuels

Fertilizers and inorganic products

Starch: $6CO_2 + 5H_2O + 680{,}000 \text{ cal} \leftrightarrow C_6H_{10}O_5 + 6O_2$

(The reaction that makes life possible)

Sugars (glucose, fructose, and sucrose)

Carbohydrates (C with a two to one ratio of H to O)

Cellulose

Fermentation (the conversion of glucose to alcohol)

$C_6H_{12}O_6 \rightarrow 2C_2H_6O + 2CO_2$

Medical drugs

Chapter 15: Transmutation of Elements

Discovery of alpha and beta radiation

Discovery of the neutron (atomic number versus atomic weight)

Fission: Uranium and plutonium

Fusion: The sun cycle

Some Essential Reference Material

1. *An Inductive Chemistry*, Robert H. Bradbury (New York: D. Appleton and Company, 1912).
2. *Laboratory Studies in Chemistry*, Robert H. Bradbury (New York: D. Appleton and Company, 1912).