Unit Title: 4 - Atomic Structure and the Periodic Table

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Course: AP Chemistry

Big Idea: 1 – Elements and Atoms

Enduring Understandings:

Enduring understanding 1.B: The atoms of each element have unique structures arising from interactions between electrons and nuclei.

Enduring understanding 1.C: Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials.

Enduring understanding 1.D: Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms.

Learning Objectives:

LO 1.5 The student is able to explain the distribution of electrons in an atom or ion based upon data.
LO 1.6 The student is able to analyze data relating to electron energies for patterns and relationships.
LO 1.7 The student is able to describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb’s law to construct explanations of how the energies of electrons within shells in atoms vary.
LO 1.8 The student is able to explain the distribution of electrons using Coulomb’s law to analyze measured energies.
LO 1.9 The student is able to predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model.
LO 1.10 Students can justify with evidence the arrangement of the periodic table and can apply periodic properties to chemical reactivity.
LO 1.11 The student can analyze data, based on periodicity and the properties of binary compounds, to identify patterns and generate hypotheses related to the molecular design of compounds for which data are not supplied.
LO 1.12 The student is able to explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from a classical shell model with the quantum mechanical model.
LO 1.13 Given information about a particular model of the atom, the student is able to determine if the model is consistent with specified evidence.
LO 1.16 The student can design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution.
Topics to Cover/In-class Activities

I. Electron Configuration
   a. Aufbau diagrams
   b. Electron Configurations
   c. Coulomb’s Law Revisited
   d. Diamagnetic and Paramagnetic Atoms

II. Some History of the Atom
   a. Evolution of models of the atom
   b. Experimental results that refined models

III. Light
   a. Wave-particle duality
   b. Characteristics of light
   c. Electromagnetic radiation
   d. Calculations with light

IV. Application of Light to the Atom
   a. Bohr model
   b. Ground state vs. excited state
   c. Light as a driving force

V. Quantum Mechanics
   a. Heisenberg’s uncertainty principle
   b. Differences between orbitals in hydrogen and multi-electron atoms

Class Activity: Light Emission Spectra - observe and sketch emission spectra of several elements; compare observed results to accepted results; describe any trend seen in line spectra within families; perform ΔE_{level} calculations, use results to compare atomic structure of H atom to other atoms and discuss the validity of Bohr’s model and the change to the quantum model
-LO 1.5, 1.8, 1.12, 1.13
-SP 1.5, 5.3 6.2, 6.3, 6.4

VI. Subatomic Particle Interactions
   a. Shielding Effect
   b. Effective Nuclear Charge
   c. Electron-electron Repulsions
   d. Coulomb’s Law

VII. Spectroscopy
    a. Absorption spectroscopy
    b. Infrared spectroscopy
    c. UV-Vis
    d. NMR/MRI
    e. PES
    f. Analyzing data from a spectrophotometer
    g. Analyzing PES data

VIII. Periodic Trends
      a. Atomic radius
      b. Ionic radii
      c. Ionization energy
d. Electron affinity

e. Metallic and nonmetallic character

Class Activity: Atomic Trends - graph atomic size, ionization energy and electronegativity versus atomic number for first 30 of the first 36 elements; predict values of missing elements based on trend
-LO 1.6, 1.7, 1.8, 1.9, 1.10, 1.11
-SP 3.1, 3.2, 3.3, 5.1, 6.1, 6.2, 6.4

Lab:

7. How Blue is My Gatorade? [inquiry lab]
   -Topics: spectroscopy, Beer’s Law, creating a standard curve, determining the concentration of an unknown
   -LO 1.15, 1.16
   -SP 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 5.1, 6.4