Chapter 3

Atomic Structure: Explaining the Properties of the Elements

Learning Objectives

8.12.2022

To satisfy the minimum requirements for this course, you should be able to:

1. **Explain the nature of electromagnetic radiation**. Be able to:
   - define the meaning of wave properties: wavelength (λ), frequency (ν) and speed (c)
   - identify the relative frequencies/energies of infrared, visible, and UV regions; and the energies of the colors in the visible spectrum (ROYGBIV)
   - perform calculations using the relationship $\lambda\nu = c$ (speed of light)
   - perform calculations using the equation $E = h\nu$ (the energy of a single quantum, photon, of light)
   - calculate the energies and wavelengths of photons absorbed or emitted by electronic transitions of a hydrogen atom (using the Rydberg equation, Eqn 3.8)

2. **Describe the quantum mechanical model of the H-atom**, including:
   - the concept of an allowed energy state as it relates to the quantum theory and line spectra
   - the wave properties of the bound electron and the interpretation of the Heisenberg uncertainty principle as it relates to orbitals, electron density distribution, and probability of "finding" the electron
   - recognizing the shapes of the *s, p,* and *d* orbitals
   - explain the difference between the ground state and excited states of an atom

3. **Describe the arrangement of electrons in multi-electron atoms or ions**. Specifically, be able to:
   - give the number and types of orbitals within each shell and subshell of an atom
   - write ground state electron configurations and orbital diagrams for atoms or ions of elements up to $Z = 36$ using the Aufbau principle, Hund's rule, and the Pauli exclusion principle, and use to predict whether the atom/ion will be diamagnetic or paramagnetic.

4. **Explain the fundamental relationship between the valence electron configurations of the elements and the organization of the periodic table**.
   - discuss what is meant by the *s, p, d,* and *f* blocks of elements in the periodic table

5. **Identify the periodic trends in sizes and ionization energies of the elements**. Be able to:
   - use the concept of effective nuclear charge (Z_{eff}) and the increasing distance of valence electrons from the nucleus when occupying higher shells of the atom to explain how and why atomic radii (sizes) and ionization energies vary across a period and down a group.
   - explain why metals form cations and non-metals form anions in ionic compounds
   - understand and explain how observed trends in the values of the successive ionization energies of elements (Table 3.2) relate to position in the periodic table.
   - explain why atoms tend to gain or lose electrons until they become isoelectronic with the nearest noble gas when forming ionic compounds

6. **Define electron affinity and be able to recognize a chemical equation for this process**