Unit 3 – Atomic Structure and Periodic Table

Unit Goals: As you work through this unit, you should be able to:

1. describe previous atomic theories and compare to our modern understanding of the atom (4.1)
2. distinguish among protons, electrons, and neutrons in terms of mass and charge. (4.2)
3. describe the structure of the atom. (4.2)
4. explain why isotopes differ and why atomic masses are not whole numbers. (4.3)
5. understand how atomic mass is calculated. (4.3)
6. describe the different electron orbitals. (5.1)
7. understand how to write electron configurations and orbital diagrams for atoms using the periodic table. (5.2)
8. understand the difference between an atom and an ion and be able to write electron configurations of various ions using the periodic table. (5.2)
9. describe quantum mechanical model and how we discovered this phenomenon using light. (5.3)
10. identify the position of groups, periods, and different chemical families on the periodic table and understand how the periodic table is organized using periodic law. (6.1)
11. explain why elements in the same family have similar properties and relate this to electron configuration. (6.2)
12. describe the trends on the periodic table of atomic size, and electronegativity and how they relate to atomic structure. (6.3)

Read: Chapters 4, 5 & 6

Assignments:

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<th>Description</th>
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<td>A1 Atomic Structure WS (goals 1-3), Chapter 4</td>
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<td>A2 Isotopes WS (goals 4-5) Chapter 4</td>
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<td>A3 Atomic Theory and Orbitals (g 6-9) Ch. 5</td>
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<td>A4 Elect Configs and orbital diagrams w/ Shorthand(g 6-9) Chapter 5</td>
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<td>A5 Period Table: Organizing the Elements(g 10-12) Chapter 6</td>
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<td>A6 Periodic Table and Trends(g 10-12) Chapter 6</td>
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Activities, Labs & Test

- Marble Lab
- Nailon Isotope Lab
- Flame Test Lab
- Chapter 4 & 5 test
- Late Lab Stamp (this stamp means you are not qualified to do lab and test corrections)

Key Terms: atom, electrons, neutrons, nucleus, protons, atomic number, mass number, atomic mass, atomic mass unit, isotope, Dalton’s atomic theory, ground state, excited state, quantum, quantum mechanical model, orbitals, Pauli’s Exclusion Principle, Hund’s Rule, Aufbau Principle, electron configuration, orbital diagrams, electron configuration, periodic table, periodic law, representative elements, period, group, metals, non-metals, alkali metals, alkaline earth metals, transition metals, halogens, noble gases, metalloids, atomic size, electronegativity,

Demo’s: Vandegraph machine, Cathode Ray Tubes, Spectrophotometers, Activity Series (Na, Li, K), Outside Atom model, Pennies in HNO₃, Zinc/Copper/Mg/Lead,
4.1 Atoms: Smallest particle of matter that retains its identity in a _______________
A. _____________ Atomic Theory.
  1. All ________________ are composed of _____ ________________ particles called __________
  2. Atoms of the same element are ________________. Atoms of any one element are ________________ from atoms of ________________ elements
  3. Atoms of different elements ______________ mix together, or can chemically combine in ___________ ________________ratios to form ________________.
  4. Chemical reactions occur when atoms are ______________, ______________, or ______________. Atoms of one element, however, are ______________ changed into atoms of ______________ element as a result of a chemical reaction.

4.2 Subatomic Particles: Actually means ______________ atom.
  A. Electrons: This is what makes elements___________________________.
    a. Located _____________________________________________.
    b. Charge is ____________________________.
    c. Electrons ________________ ____so they can___________________________.
    d. Have no _______________________  
    e. Exist at different_______________. The number of ________________can be found by looking at ________________the element  
    f. The only electrons that can bond with other atoms are the ________________
       _______________. Called _____________________________.

Thompson’s Experiment
**B. Protons:** Protons give ____________________ b/c their positive charge controls the __________ attractions of an atom, thus controlling it’s ________________

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<tr>
<td>6</td>
<td>C</td>
</tr>
<tr>
<td>Carbon</td>
<td>12.01</td>
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**Example:**
- Potassium has how many protons? __________
- Potassium (K) has how many electrons? ______________
- Potassium has how many energy levels? ____________

**Diagram here:**

K has how many outer electrons for bonding? __________

**C. Neutrons:** This is what adds to the __________ of an atom. 1 Neutron = __________.

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<tbody>
<tr>
<td>a.</td>
<td>Located in the ____________</td>
</tr>
<tr>
<td>b.</td>
<td>Charge is ______________</td>
</tr>
<tr>
<td>c.</td>
<td>Total mass of an atom from the _______________ and the _______________</td>
</tr>
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</table>

**Rutherford’s Experiment**
Fill in the grid below for each subatomic particle.

<table>
<thead>
<tr>
<th>Location in atom</th>
<th>Charge</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutrons</td>
<td></td>
<td></td>
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<tr>
<td>Electrons</td>
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4.3 Distinguishing Between Atoms = The Periodic Table

A. Atomic Number: This is the _____________ number for each element on the periodic table. It tells us how many ____________ there are for that element. Remember, the protons are positive, so they control the ________________ of each element.

1. Atomic # of carbon =
2. Atomic # of potassium =

B. Mass Number: The number of ______________ plus ______________. Remember, the mass is not affected by __________ because they are so __________.

a. The number of neutrons can be found by: __________________________

1. Oxygen with a mass number of 16 has:
2. Sodium with a mass number of 23 has:
3. How many neutrons are in carbon 14?
4. How many neutrons are in boron 11?

b. Isotopic Symbol for any element is the _____________ & _____________

ie

197
79
Au

C. Isotopes: All atoms of an element have same number of_______________. But, in nature, some atoms of the same element have different numbers of______________, they are called different_______________. This causes their masses to be different, but their ______________ stays the same b/c the neutrons are ______________ so they don’t change the _____________
Copy the three neon isotopes on page 113 below.

Problem: An atom is identified as platinum-195.
   a. What does the number represent?___________________
   b. How many protons? ______________
   c. How many neutrons?_______________________
   d. How many electrons?______________________

D. Atomic Mass
   a. Individual atoms are _________________________________.
   b. We measure the mass of atoms using _________________________________.
      i. This standard unit was set using carbon-12 which has ______________
         protons and _______________ neutrons.
      ii. Carbon-12 was given a mass of ________________________________
      iii. One atomic mass unit is _________________ of carbons mass.
      iv. Each proton and neutron has a mass of about
         _________________.
      v. The _____________________________ of an element is the
         ______________ mass of all the isotopes of an element in
         nature_______________________ This is only useful for
         _________________________ in the _____________________.

Copy Figure 4.10, pg. 115 (calculating weighted averages)
Practice Isotope Problem 1. Magnesium has three naturally occurring isotopes. 78.70% of Magnesium atoms exist as Magnesium-24 (23.9850 g/mol), 10.03% exist as Magnesium-25 (24.9858 g/mol) and 11.17% exist as Magnesium-26 (25.9826 g/mol). What is the average atomic mass of Magnesium?

Practice Isotope Problem 1. Neon has two major isotopes, Neon-20 and Neon-22. Out of every 250 neon atoms, 225 will be Neon-20 (19.992 g/mol), and 25 will be Neon-22 (21.991 g/mol). What is the average atomic mass of Neon?

5.1 Applying the Periodic table to useful models of atoms
A. Bohr Model: Uses _______________ to show the energy levels. The number of rings should match the _______________ of that element. This model is ______________________.

1. The protons in the nucleus are found by looking at the _______________.
2. The neutrons plus the protons must add up to _______________.
3. The electrons fill the shells from _______________ until they match the number of _______________. They fill in the following order _______________.
4. Each energy level is called a _______________.
   a. You can check you outer electrons to make sure they match the _______________.
   b. This model can only be used for the first 20 atoms. After that it _______________.
      i.e. Calcium 44                  i.e. lithium 7
Draw Bohr Models for the following Isotopes. Include…
  - # of Electrons in correct orbitals
  - # of Protons in nucleus
  - # of Neutrons in nucleus

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<thead>
<tr>
<th>Sulfur 34</th>
<th>Boron 10</th>
<th>Helium 3</th>
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<th>Sulfur 32</th>
<th>Boron 14</th>
<th>Helium 4</th>
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Directions: Complete the table for the following isotopes of each element:

<table>
<thead>
<tr>
<th>Element</th>
<th>Symbol</th>
<th>Number of Protons</th>
<th>Number of Electrons</th>
<th>Number of Neutrons</th>
<th>Atomic Number</th>
<th>Mass Number</th>
<th>Valence Electrons</th>
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<tbody>
<tr>
<td>Sodium</td>
<td>S</td>
<td>13</td>
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<td>Mercury</td>
<td>Hg</td>
<td>120</td>
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F

A. In 1926, the Austrian physicist Erwin Schrödinger took atomic models one step further. He has given us the modern description of the electrons in atoms, called the _____________________________ ________________ ____________.

Atomic Orbitals – Page 131
a. What is a principal energy level?
b. What are sublevels?
c. What are orbitals?
d. What are the four “letters” used to denote the energy sublevels?
e. What shape do the first 3 atomic orbitals take? Remember, they are “clouds” of probability. (draw them below)
S shape

P shape

D shape

(f shape clouds are too complicated to draw…)

The S sublevel has _________ orbital, therefore can hold ________ electrons.
The P sublevel has ________ orbitals, therefore can hold ________ electrons.
The D sublevel has_________ orbitals, therefore can hold _______ electrons.
The F sublevel has _________ orbitals, therefore can hold __________ electrons.

f. Three different views of the Quantum Mechanical Model.
   1. Aufbau Diagram: Try Chromium

   2. Electron Configuration Pyramid” (see poster in room):

   1s
   2s  2p
   3s  3p  3d
   4s  4p  4d  4f
   5s  5p  5d  5f
   6s  6p  6d
   7s  7p  7d
3. Block Diagram,

There are 3 general rules that guide us when writing electron configurations. They are:

1. Aufbau principle: Electrons occupy ____________energy level first
2. Pauli Exclusion Principle: Only ______ electrons per orbital, each with ____________ spin.
3. Hund’s Rule: When electrons occupy ____________orbitals of the ____________ energy, ______ electron enters each orbital with the ____________spin until each orbital in that level has one electron. ____________electrons then occupy each orbital so they _______ with opposite spins.

**Problem:** Use these rules to write electron configurations and orbital diagrams for the following atoms:

a. Lithium

b. Fluorine

c. Rubidium

d. Nickel
• **Ions?** Atoms that have _______________ or __________electrons.

Li⁺¹, lithium that has _________one electron.

F⁻¹, fluorine that has _________ one electron

---

**A. Shorthand Method:** We can use the _______________ __________ Electron configurations from now on. Let’s try a few. Write down the ______ noble gas that was filled on the way to finding your element. Then only do the electron configuration for the ________________ electrons.

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Phosphorus

Germanium

Argon

Calcium ion, Ca⁺²

Oxygen ion, O⁻²
5.3 Physics and the Quantum Mechanical Model
A. Light has behavior like a particle and behavior like a wave.

Sunlight is the full electromagnetic spectrum of wavelengths. We only see a small sliver called visible light which ranges between ________________________________.

Copy the full electromagnetic spectrum below.

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A. Atomic Spectra
1. When atoms __________ energy, electrons move into __________ energy levels.
   These electrons then lose energy by __________ light when they return to __________ energy levels.
2. Each element will emit its own unique __________ __________ __________ __________ when energy is added. Each discrete line, or color represents one exact __________ or __________ released as electrons return to __________ states, or resting energy levels.

Diagram Hydrogen below
6.1 Organizing Elements

A. Metals, Non-Metals, & Metalloids
   a. ______________: ___________ of the ladder(exception is_____________)
      i. Conduct______________: means they can pass________________
      ii. ____________: Means they can be pounded________________
      iii. ____________: Means they can be draw into thin ______________
      iv. ____________ at room temp except______________
   b. ______________: ___________ of the ladder
      i. Do not ____________ __________________(exception_______________ vs. ______________)
      ii. ____________: ____________ when hit with hammer
      iii. Many are ____________ at room temp
      iv. ____ , ____ , ____ , ____ , ____ are solids at room temp
      v. ____ , is a liquid at room temp
   c. ______________: ___________ two sides of the ladder
      i. These have ____________ properties of ____________ and ______________
   d. The ______________ groups are called __________________________. This is b/c the group number tells you _____________ for that group of elements. Each group has the exact same ____________ or ____________________________
      i. Group 1A metals are called __________________.
         -Their valence electrons follow what pattern?
      ii. Group 2A metals are called ____________
         -Their valence electrons follow what pattern?
      iii. Group 7A are called ____________
         -Their valence electrons follow what pattern?
iv. Group 8A are called __________
   - Think
   - Their valence electrons follow what pattern?

e. The ______________groups are called __________________________ because metals with ______ energy sublevels in their ______________ shell can __________________________ their valence electrons. There are of course three exceptions(______, ______, ______)

v. ______________metals have valence electrons that occupy an _____energy sublevel and the nearest _____energy sublevel

vi. ______________transition metals have valence electrons that occupy an _____ energy sublevel and the nearest _____energy sublevel. These are found ____________ the periodic table.

6.2 Periodic Trends
A. Atomic Size is measured as the atomic ____________ of an atom by taking __________ the distance between two atoms of the same ___________. See diagram below of Florine and Iodine

a. Trends in Group Size: As you go __________ a group, size _______________ because _____________ levels are increasing, cause valence electrons to fly _______________ away from the _________________.

b. Trends in Period Size: As you go across a period, to the _____________, the valence electrons occupy the ________________level, but the additional ______________ in the nucleus cause greater ______, resulting in _____________ atomic radius.
B. Electronegativity: The ability of an atom to attract electrons when the atom is in a compound.

a. Electronegativity _________ as you go down a group because the _______ nucleus becomes _______ from the valence electrons, thus _______ it’s influence.

b. Electronegativity _________ as you move _______ across the periodic table because the proton influence _______ along the same principal energy level.

Diagram how electronegativity affects ion formation below between fluorine and cesium. Include relative sizes of atoms to help illustrate why they are so different.