Unit 2

The Atom

Chemistry Assignments and Objectives

EQ: Describe the atom, its components and how atoms can differ.

Lesson 1 – Learning Targets

1. List the three subatomic particles (proton, neutron and electron.) Give their relative charges and masses.
2. Describe the structures of an atom.

Lesson 1 – Homework Problems

1. How many protons and electrons are in each of the following neutral atoms?
   a. Boron $\text{5}^{p} + 5e^{-}$
   b. Radon $\text{86}^{p} + 86e^{-}$
   c. Platinum $\text{78}^{p} + 78e^{-}$
   d. Magnesium $\text{12}^{p} + 12e^{-}$

2. A neutral atom contains 66 electrons. What element is it? Dysprosium

3. A neutral atom contains 14 protons. What element is it? Silicon

4. Determine the number of protons, electrons and neutrons for the following isotopes:
   a. Neon-22 $\text{10}^{p} 10e^{-} 12n$
   b. Calcium-46 $\text{20}^{p} 20e^{-} 26n$
   c. Oxygen-17 $\text{8}^{p} 8e^{-} 9n$
   d. Iron-57 $\text{26}^{p} 26e^{-} 31n$
   e. Zinc-64 $\text{30}^{p} 30e^{-} 34n$
   f. Mercury-204 $\text{80}^{p} 80e^{-} 124n$

Lesson 2 – Learning Targets

1. Describe how isotopes of an atom are different from each other.
2. Know that an isotope’s mass number is the number of protons and neutrons added together.
3. Determine the atomic mass of an element.

Lesson 2 – Homework Problems

5. Boron has two naturally occurring isotopes: boron-10 (abundance = 19.8%), boron-11 (abundance = 80.2%). Calculate the atomic mass of boron. $10(0.198) + 11(0.802) = 10.8 \text{ amu}$

6. Calculate the atomic mass of magnesium. The three magnesium isotopes have atomic masses and relative abundances of 23.985 amu (78.99%), 24.996 amu (10.00%) and 25.982 (11.01%).

   $23.985(0.7899) + 24.996(0.1000) + 25.982(0.1101) = 24.31 \text{ amu}$
Lesson 3 – Learning Targets

1. Explain the Bohr model of the atom.
2. Define “ground state.”
3. Interpret hydrogen’s line spectrum.
4. Solve problems using hydrogen’s line spectrum.
5. Understand that wavelength and frequency have an inverse relationship.
6. Describe the wave-particle duality that light and matter both have.

Lesson 3 – Homework Problems

Bohr Model and Electromagnetic Spectrum Practice

Also refer to “Chem. Ref. Table” page 8

Use the Bohr Model of the Hydrogen Atom and the Electromagnetic Spectrum in the reference tables to answer the following questions:

1. When an electron in an excited state moves from n=6 to n=2, what wavelength of energy is emitted? What region of the EM spectrum is this wavelength located? \[410\text{nm} = 4.10 \times 10^{-7}\text{m}\] \text{visible}

2. In what region of the EM spectrum is energy emitted when an electron moves from n=5 to n=3? \text{infra red}

3. When an electron in an excited state moves from n=4 to n=1, what wavelength of energy is emitted? In what region of the EM spectrum is this wavelength located? \[97\text{nm} = 9.7 \times 10^{-8}\text{m}\] \text{ultra violet}

4. When an electron in the excited state moves from n=3 to n=2, what wavelength of energy is emitted? \[656\text{nm} = 6.56 \times 10^{-7}\text{m}\]

5. An emission spectrum containing three lines is obtained from an excited atom. For each line in Column A, write the letters of the matching transitions shown in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. line x, 434 nm</td>
<td>a. 6 to 2</td>
</tr>
<tr>
<td>b. line y, 656 nm</td>
<td>b. 3 to 2</td>
</tr>
<tr>
<td>c. line z, 410 nm</td>
<td>c. 5 to 2</td>
</tr>
</tbody>
</table>
6. What color of visible light will each line emit?
   
   blue line x, 434 nm = 4.34 x 10^{-7} m
   red line y, 656 nm = 6.56 x 10^{-7} m
   violet line z, 410 nm = 4.10 x 10^{-7} m

7. A fourth transition also occurs at 103 nm. Why doesn't this line show up on the line spectrum?
   103 nm is in the UV range, not in the visible part of the spectrum.

8. What end of the EM spectrum consists of the highest frequencies?
   gamma

9. What end of the EM spectrum consists of the longest wavelengths?
   radio

10. Which portion of the EM spectrum might energy be emitted as color that can be seen?
    visible

11. If energy is emitted from an atom with a wavelength of 10^{-5} m, what kind of radiation is emitted?
    infrared

12. A wavelength of 5.8 x 10^{-7} m is emitted from an atom. What type of radiation is emitted? (Be specific.)
    visible (yellow)

13. What types of electromagnetic energy has a frequency just less than that of ultraviolet light?
    visible

14. What types of waves have energy just less than that of visible light?
    infrared

15. Wavelengths of 10^{-13} m are emitted from a source. In what region of the EM spectrum is this energy located? Should there be any concern with handling this source?
    gamma
    yes. Short wavelength means high frequency which means damaging to cells.

Lesson 4 – Learning Targets

1. Apply the Pauli exclusion principle, the Aufbau principle, and Hund’s rule to write electron configurations and orbital (box) diagrams.
2. Define valence electrons.
3. Write noble gas electron configurations.

Lesson 4 – Homework Problems

1. Write the standard electron configurations for the following elements:
   a. Bromine (Br)  b. Strontium (Sr)  c. Antimony (Sb)  d. Titanium (Ti)
   1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^10 4p^5
   1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^10 4p^6 5s^2 4d^{10} 5p^3

2. How many electrons are in orbitals related to the third energy level of a sulfur atom?
   1s^2 2s^2 2p^6
   \( \_6 \)

3. How many electrons occupy p orbitals in a chlorine atom?
   1s^2 2s^2 2p^6 3s^2 3p^5
   \( \_11 \)

4. What elements have the following electron configurations?
   a. [Kr] 5s^2 4d^{10} 5p
   b. [Xe] 6s^2
   Indium
   Barium
5. Draw the electron-dot structure for the following element:
   \[ \text{Mg}^+ \quad \text{S}^- \quad \text{Br}^- \quad \text{Rb}^- \quad \text{Tl}^- \quad \text{Xe}^- \]

Unit 2 Review

SUBATOMIC PARTICLE PRACTICE

1. What information about the subatomic makeup of an atom is given by the following?
   a) atomic number  \#P also \#e\textsuperscript{−} for neutral atoms
   b) mass number  \#P + \#n combined
   c) mass number – atomic number  \#n

2. Determine the number of protons, neutrons, and electrons present in each of the following atoms.
   (mass # = top number, atomic # = bottom number)
   a) \text{^{28}_{14}Si}  \quad \text{P = 14} \quad \text{n = 14} \quad \text{e\textsuperscript{−} = 14}
   b) \text{^{197}_{79}Au}  \quad \text{P = 79} \quad \text{n = 118} \quad \text{e\textsuperscript{−} = 79}
   c) \text{^{40}_{18}Ar}  \quad \text{P = 18} \quad \text{n = 22} \quad \text{e\textsuperscript{−} = 18}
   d) \text{^{64}_{29}Cu}  \quad \text{P = 29} \quad \text{n = 35} \quad \text{e\textsuperscript{−} = 29}
   e) \text{^{39}_{19}K}  \quad \text{P = 19} \quad \text{n = 20} \quad \text{e\textsuperscript{−} = 19}
   f) \text{^{133}_{55}Cs}  \quad \text{P = 55} \quad \text{n = 78} \quad \text{e\textsuperscript{−} = 55}

3. Write the symbol, atomic number and atomic mass for the atoms with the following characteristics.
   a) Contains 15 neutrons and 13 protons.
      \text{^{28}_{13}Al}
   b) Atomic number is 41.
      \text{^{93}_{41}Nb}
   c) Contains 33 electrons and 42 neutrons.
      \text{^{75}_{33}As}
   d) Iron contains 84 subatomic particles.
      \text{^{58}_{26}Fe}
   e) Rubidium that contains 87 nucleons.
      \text{^{87}_{37}Rb}

4. Give the definition of each:
   a. Proton
   b. Electron
   c. Atomic number
   d. Atomic mass (average)
   e. Isotope
   f. Neutron
   g. Nucleus
   h. Mass number
   i. Atomic mass unit (amu)
   j. \#P + \#n in particular isotope
   k. Used to measure atoms' masses. Equivalent to \frac{1}{12} of a C-12 atom
   l. Positive particle in nucleus
   m. Tiny negative particle around nucleus
   n. \# of protons
   o. Weighted average of the isotopes' masses
   p. Specific atom that has a certain \# of neutrons
   q. Particle in nucleus with no change
   r. Center of atom, contains \#P + \#n; has almost all the mass and very little volume of atom
Write electron configurations for the following elements.

**Standard Form**
1. boron (B) \[\text{1s}^2 \text{2s}^2 \text{2p}^1\]
2. phosphorus (P) \[\text{1s}^2 \text{2s}^2 \text{2p}^6 \text{3s}^2 \text{3p}^3\]
3. neon (Ne) \[\text{1s}^2 \text{2s}^2 \text{2p}^6\]
4. scandium (Sc) \[\text{1s}^2 \text{2s}^2 \text{2p}^6 \text{3s}^2 \text{3p}^6 \text{4s}^2 \text{3d}^1\]
5. krypton (Kr) \[\text{1s}^2 \text{2s}^2 \text{2p}^6 \text{3s}^2 \text{3p}^6 \text{4s}^2 \text{3d}^{10} \text{4p}^6\]
6. beryllium (Be) \[\text{1s}^2 \text{2s}^2\]
7. sulfur (S) \[\text{1s}^2 \text{2s}^2 \text{2p}^6 \text{3s}^2 \text{3p}^4\]
8. barium (Ba) \[\text{1s}^2 \text{2s}^2 \text{2p}^6 \text{3s}^2 \text{3p}^6 \text{4s}^2 \text{3d}^{10} \text{4p}^6 \text{5s}^2 \text{4d}^{10} \text{5p}^6 \text{6s}^2\]

**Short Form**
9. strontium (Sr) \[[\text{Kr}] \text{5s}^2\]
10. sodium (Na) \[[\text{Ne}] \text{3s}^1\]
11. potassium (K) \[[\text{Ar}] \text{4s}^1\]
12. chlorine (Cl) \[[\text{Ne}] \text{3s}^2 \text{3p}^5\]
13. gallium (Ga) \[[\text{Ar}] \text{4s}^2 \text{3d}^{10} \text{4p}^1\]
14. cesium (Cs) \[[\text{Xe}] \text{6s}^1\]

**Identification**
15. \[[\text{Ar}] \text{4s}^2 \text{3d}^1\] Sc
16. \[[\text{Kr}] \text{5s}^2 \text{4d}^{10} \text{5p}^5\] I
17. \[[\text{Ar}] \text{4s}^2 \text{3d}^6\] Fe
18. \[[\text{Xe}] \text{6s}^2\] Ba
19. \[[\text{He}] \text{2s}^2 \text{2p}^3\] N

20. Rank the following electromagnetic waves in order of increasing frequency. Microwaves, Ultraviolet, Infrared, Visible Light, X-rays, Radio waves, Gamma rays.

Radio, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays

21. Identify each of the following as either chemical or physical properties of the substance.
   a. Aluminum bends easily physical
   b. Copper sulfate dissolves in water physical
   c. Magnesium burns in air chemical
   d. Gold jewelry is unaffected by perspiration chemical
   e. Baking soda is a white powder physical
   f. Fluorine is a highly reactive element chemical

22. Identify each of the following as either chemical or physical changes.
   a. A match lights when struck. chemical
   b. Air is squeezed by a pump and forced into a tire physical
   c. A lump of gold is pounded into a large, thin sheet. physical
   d. Baking powder bubbles and gives off CO₂ when it is moistened. chemical
   e. A pan of water boils on the stove. physical
   f. Hydrogen sulfide gas causes silver to tarnish. chemical

23. A friend tells you that a newspaper is completely gone because it was burned up in a fire. Use the law of conservation of matter to write an explanation for what really happened to the newspaper.

Most of it became the gases CO₂ and H₂O.
It looks like it's mostly gone because the gases diffusion into the air.
24. Complete the following table.

<table>
<thead>
<tr>
<th>Element</th>
<th>Protons</th>
<th>Neutrons</th>
<th>Electrons</th>
<th>Atomic Number</th>
<th>Mass Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>13</td>
<td>14</td>
<td>13</td>
<td>13</td>
<td>27</td>
</tr>
<tr>
<td>Cu</td>
<td>29</td>
<td>0</td>
<td>29</td>
<td>29</td>
<td>64</td>
</tr>
<tr>
<td>Sr</td>
<td>38</td>
<td>50</td>
<td>38</td>
<td>38</td>
<td>88</td>
</tr>
<tr>
<td>Br</td>
<td>35</td>
<td>45</td>
<td>35</td>
<td>35</td>
<td>80</td>
</tr>
</tbody>
</table>

Units 1 & 2 Review

1. An atom has 8 protons, 8 neutrons and 8 electrons. What is the name of this isotope? What is its mass number?
   Answer: oxygen-16, 16
2. How many significant figures are in \(3.11 \times 10^{12}\)?
   Answer: 3
3. How many neutrons are found in an atom of carbon-14?
   Answer: 8
4. Using sig figs, solve:
   a. \(3.3 \text{ m} + 33.123 \text{ m} + 22.22 \text{ m} = 58.65 \text{ m}\)
   b. \(2.85 \text{ cm} \times 3.3 \text{ cm} = 9.4 \text{ cm}^2\)
5. Write the following in scientific notation:
   a. 123,000
   b. 0.000303
   Answer: \(3.30 \times 10^{-4}\)
6. Define isotope: atom with a certain number of neutrons
7. Convert 540 nm to m: \(5.40 \times 10^{-7} \text{ m}\)
8. Convert 333 mg into grams:
   Answer: \(3.33 \text{ g}\)
9. The shorthand electron configuration \([\text{Ar}]4s^23d^{10}4p^1\) belongs to which atom?
   Answer: Ga
10. What is the electron configuration for silicon?
    \(1s^22s^22p^63s^23p^2\)
11. How many electrons are in the 3p sublevel of aluminum?
    Answer: 1
12. What is the orbital diagram for gallium?
    \(1s^22s^22p^63s^23p^2\)
13. A bottle contains 4.40 mL of a liquid. The total mass of the bottle and the liquid together is 9.90 g. The mass of the empty bottle is 3.30 g. What is the total density of the liquid?
    \(D = \frac{m}{V} = \frac{6.60 \text{ g}}{4.40 \text{ mL}} = 1.50 \text{ g/mL}\)
14. What is the density of vinegar if 15.0 mL has a mass of 16.0 g? \(D = \frac{m}{V} = \frac{16.0 \text{ g}}{15.0 \text{ mL}} = 1.07 \text{ g/mL}\)
15. Using the Bohr model of hydrogen in the reference packet, what color of light is given off by a hydrogen atom as its electron falls from n=6 to n=2? What region is this?
    Answer: violet, visible
16. Which type of electromagnetic radiation has a longer wavelength than microwaves? radio
17. What element contains 29 electrons and is used in electrical wiring?
    Answer: copper (Cu)
18. Homogeneous or heterogeneous mixture is
   a. Sugar water
   b. Smog
   c. Koolaid
   d. Chocolate chip ice cream
   Answer: heterogeneous
19. Physical or chemical change?
   a. Burning a candle
   b. Dissolving salt
   c. Melting ice
   d. Crushing a can
   Answer: physical
20. Where are each of the following located? What are the charges and masses of the following?
   a. Electron
   b. Proton
   c. Neutron

   Electron cloud
   Nucleus
   Nucleus
   - change
   Very small mass
   + charge
   No change
   o amu
   a amu

21. Which are elements and which are compounds?
   a. KCl
   b. S
   c. H₂O
   d. Cl
   e. NO₂
   f. SO₂

   compound  compound  element  compound  element  compound

22. Draw the electron dot diagram for:
   a. Sodium
   b. Xenon
   c. Gallium
   d. Sulfur
   e. Silicon
   f. Bromine

   Na⁺  Xe  Ga  S  Si  Br⁻

23. How many valence electrons are in the following:
   a. Calcium
   b. Oxygen
   c. Carbon
   d. Fluorine
   e. Lithium
   f. Helium

   2  6  4  7  1  2

24. Draw the orbital filling diagram for the following:
   a. Carbon
   b. Argon
   c. Magnesium
   d. Nitrogen

   a, b, c, and d have similar structures with filled 2s and 3s orbitals.

   a.
   1s²  2s²  2p²

   b.
   1s²  2s²  2p⁶

   c.
   1s²  2s²  2p⁶

   d.
   1s²  2s²  2p²