After studying chapter 4, you should be able to:

- Explain the law of conservation of mass, the law of definite proportions, and the law of multiple proportions.
- Summarize the five essential points of Dalton’s atomic theory.
- Distinguish among protons, neutrons, and electrons in terms of their relative masses and charges.
- Explain the structure of an atom, including the location of the proton, neutron, and electron with respect to the nucleus.
- Explain how atomic number identifies an element.
- Infer the number of protons, electrons, and neutrons using the atomic number and mass number of a neutral atom or an ion.
- Summarize the observed properties of cathode rays that led to the discovery of the electron.
- Summarize Rutherford’s experiment that led to the discovery of the nucleus.
- Explain how Millikan’s oil drop experiment determined the charge on an electron.
- Explain how isotopes of an element differ.
- Explain, using concepts of isotopes, why the atomic masses of elements are not whole numbers.
- Calculate the average atomic mass of an element from isotope data.
- State the names and symbols of elements 11-30
- Relate the formula of a compound to the numbers and types of atoms in the compound.
- Explain the roles of Mendeleev and Moseley in the development of the periodic table.
- Distinguish between a group and a period in the periodic table.
- Categorize the elements as main group element, noble gas, transition metal, metalloid, or inner transition metal (the lanthanides and actinides).
- Compare the properties of metals, nonmetals and metalloids.
- Infer the charges of monatomic ions from the location of the parent element in the periodic table.
- State the seven diatomic elements.
- Describe physical properties of common elements

Problems for you to try

1. Describe the important contribution of each of the following scientists:
   a) Democritus
   b) Lavoisier
   c) Proust
2. Complete the following table on the subatomic particles.

<table>
<thead>
<tr>
<th>Subatomic particle</th>
<th>Location in the atom</th>
<th>Electrical charge</th>
<th>Mass in amu</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Sketch a picture model of a boron atom, showing the relative locations of the subatomic particles.

4. Complete the following table on atomic structure.

<table>
<thead>
<tr>
<th>Atom or ion</th>
<th>Atomic number</th>
<th>Mass number</th>
<th>Number of protons</th>
<th>Number of neutrons</th>
<th>Number of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{193}\text{Ir}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{122}\text{Sb}^{5+}$</td>
<td>$^{51}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$^{78}\text{Se}^{2-}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. How does a cation form from a neutral atom? How does an anion form from a neutral atom?

6. There are three stable isotopes of argon: argon-36, argon-38, and argon-40. What do the atoms of these isotopes have in common? What would be different about their atoms?

7. Why are the atomic masses listed in the periodic table not reported as integers?

8. Calculate the average atomic mass of lithium which occurs as two isotopes that have the following atomic masses and abundance in nature: 6.017 amu, 7.30%; and 7.018 amu, 92.70%.
9. Explain each of the major statements of Dalton's atomic theory.

10. Complete the following table

<table>
<thead>
<tr>
<th>Group number</th>
<th>Group Name</th>
<th>Typical ion charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alkaline earth metals</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Varies</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Doesn't form ions</td>
</tr>
</tbody>
</table>

11. List typical properties of metals.

12. List typical properties of nonmetals.

13. Where are metals, nonmetals and metalloids found in the periodic table?
14. Are the following elements metals, nonmetals, or metalloids?
   a. iodine
   b. manganese
   c. osmium
   d. sulfur
   e. uranium
   f. radon
   g. barium
   h. silicon

15. Describe the experiments done by the following scientists and explain their significance.
    Include sketches!
    a) Thomson
    b) Rutherford
    c) Millikan
16. Compare and contrast Mendeleev’s and Moseley’s contributions to the development of the periodic table.

17. How many atoms of each element are present in each of the following chemical formulas?
   a) $\text{Na}_2\text{SO}_4$
   b) $\text{Fe(NO}_3\text{)}_3$
   c) $2\text{(NH}_4\text{)}_3\text{PO}_4$
   d) $\text{C}_9\text{H}_8\text{O}_4$ (aspirin)
   e) $3\text{C}_{12}\text{H}_{22}\text{O}_{11}$ (sucrose)

18. What is wrong with this diagram of a cathode ray tube? How should it look? Explain your answer.
19. Identify the law that is depicted by the following picture models. Give reasons to justify your choice. Then, identify the scientist who discovered this law.

a.

\[
\begin{array}{c}
\text{\textbullet\textbullet\textbullet\textbullet} \xrightarrow{\text{\textbullet\textbullet\textbullet}} \text{\textcircled{\textbullet\textbullet}} + \text{\textbullet\textbullet\textbullet\textbullet} \\
32\text{ g oxygen} & 4\text{ g hydrogen}
\end{array}
\]

vs.

\[
\begin{array}{c}
\text{\textbullet\textbullet\textbullet} \xrightarrow{\text{\textbullet\textbullet\textbullet}} \text{\textcircled{\textbullet\textbullet}} + \text{\textbullet\textbullet\textbullet} \\
64\text{ g oxygen} & 8\text{ g hydrogen}
\end{array}
\]

b.

\[
\begin{array}{c}
\text{\textcircled{\textbullet\textbullet\textbullet\textbullet}} \xrightarrow{\text{\textbullet\textbullet\textbullet}} \text{\textcircled{\textbullet\textbullet\textbullet}} & \text{\textcircled{\textbullet\textbullet\textbullet}} \\
28.02\text{ grams} & 6.06\text{ grams} & 34.08\text{ grams}
\end{array}
\]

c.

\[
\begin{array}{c}
\text{\textbullet\textbullet\textbullet} \xrightarrow{\text{\textbullet\textbullet\textbullet}} \text{\textcircled{\textbullet\textbullet\textbullet}} \\
\text{\textbullet\textbullet\textbullet} \xrightarrow{\text{\textbullet\textbullet\textbullet}} \text{\textcircled{\textbullet\textbullet\textbullet}}
\end{array}
\]