The atomic masses of the two stable isotopes of boron, $^{10}$B (19.78%) and $^{11}$B (80.22%), are 10.0129 amu and 11.0093 amu, respectively. Calculate the average atomic mass of boron.

$\left(0.1978\right)(10.0129) + \left(0.8022\right)(11.0093) = 10.81 \text{ amu}$

The atomic masses of $^{35}$Cl (75.53%) and $^{37}$Cl (24.47%) are 34.968 amu and 36.956 amu, respectively. Calculate the average atomic mass of chlorine. The percentages in parentheses denote the relative abundances.

$\left(0.7555\right)(34.968) + \left(0.2447\right)(36.956) = 35.45 \text{ amu}$

Assume that element Uus is synthesized and that it has the following isotopes:

$^{284}$Uus (283.9 amu), 21.00%  
$^{285}$Uus (284.8 amu), 31.54%  
$^{286}$Uus (287.8 amu), 47.46%  

What is the value of the average atomic mass that could be listed on the periodic table?

$\left(283.9\right)(0.2100) + \left(284.8\right)(0.3154) + \left(287.8\right)(0.4746) = 286.03 \text{ amu}$
The Structure of the Atom

Section 4.1 Early Theories of Matter
In your textbook, read about the philosophers, John Dalton, and defining the atom.

For each statement below, write true or false.

1. Ancient philosophers regularly performed controlled experiments.

2. Philosophers formulated explanations about the nature of matter based on their own experiences.

3. Both Democritus and Dalton suggested that matter is made up of atoms.

4. Dalton's atomic theory stated that atoms separate, combine, or rearrange in chemical reactions.

5. Dalton's atomic theory stated that matter is mostly empty space.

6. Dalton was correct in thinking that atoms could not be divided into smaller particles.

7. Dalton's atomic theory stated that atoms of different elements combine in simple whole-number ratios to form compounds.

8. Dalton thought that all atoms of a specific element have the same mass.

9. Democritus proposed that atoms are held together by chemical bonds, but no one believed him.

10. Dalton's atomic theory was based on careful measurements and extensive research.

11. There are no instruments powerful enough to magnify atoms so that they can be seen.

12. The smallest particle of an element that retains the properties of that element is called an atom.
Section 4.4 Unstable Nuclei and Radioactive Decay

In your textbook, read about radioactivity.

For each item in Column A, write the letter of the matching item in Column B.

**Column A**

- 1. The rays and particles that are emitted by a radioactive material
- 2. A reaction that involves a change in an atom's nucleus
- 3. The process in which an unstable nucleus loses energy spontaneously
- 4. Fast-moving electrons

**Column B**

- a. nuclear reaction
- b. beta radiation
- c. radiation
- d. radioactive decay

In your textbook, read about types of radiation.

Use the diagram to answer the questions.

5. Which plate do the beta particles bend toward? Explain.
   
   **positive plate attracts the negative**

6. Explain why the gamma rays do not bend.
   
   **Gamma rays have no charge**

7. Explain why the path of the beta particles bends more than the path of the alpha particles.
   
   **Beta particles are less massive and are easier to bend off their path.**

Complete the following table of the characteristics of alpha, beta, and gamma radiation.

<table>
<thead>
<tr>
<th>Radiation Type</th>
<th>Composition</th>
<th>Symbol</th>
<th>Mass (amu)</th>
<th>Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Alpha</td>
<td>Helium nucleus</td>
<td>( _{4}^{4}\text{He} )</td>
<td>4</td>
<td>2+</td>
</tr>
<tr>
<td>9. Beta</td>
<td>Electrons</td>
<td>( _{0}^{2}\text{e} )</td>
<td>( \frac{1}{1840} )</td>
<td>1-</td>
</tr>
<tr>
<td>10. Gamma</td>
<td>High-energy electromagnetic radiation</td>
<td>( _{0}^{0}\gamma )</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The positive plate attracts the negative Beta particles.

Gamma rays have no charge, so they are unaffected by the electric field.

Beta particles are less massive and are easier to bend off their path.

Alpha 
\[ ^{4}He \] 4amu \ 2+ 

Beta 
\[ ^{0}B \] 1/1840amu \ 1- 

Gamma High energy light 0amu 0 charge
# Vocabulary Review

Match the correct vocabulary term to each numbered statement. Write the letter of the correct term on the line.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. defined as $\frac{1}{12}$ the mass of a carbon-12 atom</td>
<td>a. isotopes</td>
</tr>
<tr>
<td>2. central core of an atom, which contains most of the atom's mass</td>
<td>b. neutrons</td>
</tr>
<tr>
<td>3. a vertical column of elements in the periodic table</td>
<td>c. atom</td>
</tr>
<tr>
<td>4. subatomic particles with no charge</td>
<td>d. electrons</td>
</tr>
<tr>
<td>5. positively charged subatomic particles</td>
<td>e. atomic number</td>
</tr>
<tr>
<td>6. the smallest particle of an element that retains its identity in a chemical reaction</td>
<td>f. atomic mass unit</td>
</tr>
<tr>
<td>7. the number of protons in the nucleus of an element</td>
<td>g. group</td>
</tr>
<tr>
<td>8. negatively charged subatomic particles</td>
<td>h. nucleus</td>
</tr>
<tr>
<td>9. atoms with the same number of protons but different numbers of neutrons</td>
<td>i. periodic table</td>
</tr>
<tr>
<td>10. an arrangement of elements according to similarities in their properties</td>
<td>j. protons</td>
</tr>
</tbody>
</table>
Chapter Quiz

Fill in the word(s) that will make each statement true.

1. Dalton's atomic theory included the idea that the atoms of different elements can chemically combine in ___1___ ratios.

2. An atom is the smallest particle of an element that retains its identity in a ___2___.

3. ___3___ are subatomic particles with a negative charge.

4. The nucleus of an atom is composed of ___4___ and protons.

5. A neutron has no charge, but its mass is almost the same as that of a ___5___.

6. The number of protons in an atom is called its ___6___ number.

7. There are 10 neutrons and ___7___ electrons in an atom of oxygen-18.

8. Isotopes of an element have different numbers of neutrons. They also have different ___8___ numbers.

9. The total number of protons, neutrons, and electrons in an atom of silver-109 (atomic number 47) is ___9___.

10. The mass number of an element with 14 electrons and 16 neutrons is ___10___.

11. The horizontal rows of the periodic table are called ___11___.

12. The elements in the periodic table are listed in order of increasing ___12___.

1. ___whole___

2. ___chemical Rxn___

3. ___electron___

4. ___neutron___

5. ___proton___

6. ___Atomic #___

7. ___8___

8. ___mass___

9. ___47P, 62N, 47e___

10. ___30___

11. ___periods___

12. ___Atomic ___
Part B  True-False
Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

11. The atomic number of an element is the sum of the protons and electrons in an atom of that element.
   NT

12. The atomic number of an atom is the total number of protons in an atom of that element.
   AT

13. An atom of nitrogen has 7 protons and 7 neutrons.
    ST

14. Relative atomic masses are expressed in amus.
    AT

15. The number of neutrons in the nucleus can be calculated by subtracting the atomic number from the mass number.
    AT

Part C  Matching
Match each description in Column B to the correct term in Column A

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. atomic number</td>
<td>a. atoms that have the same number of protons but different numbers of neutrons</td>
</tr>
<tr>
<td>17. periodic table</td>
<td>b. weighted average mass of the atoms in a naturally occurring sample of an element</td>
</tr>
<tr>
<td>18. mass number</td>
<td>c. equals the number of neutrons plus the number of protons in an atom</td>
</tr>
<tr>
<td>19. group</td>
<td>d. ( \frac{1}{12} ) the mass of a carbon-12 atom</td>
</tr>
<tr>
<td>20. isotopes</td>
<td>e. the number of protons in the nucleus of an atom of an element</td>
</tr>
<tr>
<td>21. atomic mass unit (amu)</td>
<td>f. an arrangement of elements according to similarities in their properties</td>
</tr>
<tr>
<td>22. atomic mass</td>
<td>g. a vertical column of elements in the periodic table</td>
</tr>
<tr>
<td>23. period</td>
<td>h. a horizontal row of the periodic table</td>
</tr>
</tbody>
</table>

Part D  Questions and Problems
Solve the following problem in the space provided.

24. Given the relative abundance of the following naturally occurring isotopes of oxygen, calculate the average atomic mass of oxygen.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Relative Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>oxygen-16</td>
<td>99.76%</td>
</tr>
<tr>
<td>oxygen-17</td>
<td>0.037%</td>
</tr>
<tr>
<td>oxygen-18</td>
<td>0.204%</td>
</tr>
</tbody>
</table>

\[ \text{Average atomic mass} = \frac{16.00 	ext{ amu} \times 0.9976 + 17.00 	ext{ amu} \times 0.0037 + 18.00 \text{ amu} \times 0.0020}{1} = 15.9996 \text{ amu} \]
Section 4.2 Subatomic Particles and the Nuclear Atom

In your textbook, read about discovering the electron and the nuclear atom.

For each item in Column A, write the letter of the matching item in Column B.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Proposed the nuclear atomic model</td>
<td>a. Thomson</td>
</tr>
<tr>
<td>2. Determined the mass-to-charge ratio of an electron</td>
<td>b. Millikan</td>
</tr>
<tr>
<td>3. Calculated the mass of an electron</td>
<td>c. Rutherford</td>
</tr>
</tbody>
</table>

Draw and label a diagram of each atomic model.

4. plum pudding model

A drawing that looks like a ball of chocolate chip cookie dough

5. nuclear atomic model

Looks like a peach with a pit

In your textbook, read about the discovery of protons and neutrons.

Complete the following table of proton, electron, and neutron characteristics.

<table>
<thead>
<tr>
<th>Particle</th>
<th>Symbol</th>
<th>Location</th>
<th>Relative Charge</th>
<th>Relative Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Proton</td>
<td>( p^+ )</td>
<td>In the nucleus</td>
<td>1(^+)</td>
<td>1 amu</td>
</tr>
<tr>
<td>7. Neutron</td>
<td>( n^0 )</td>
<td>In the nucleus</td>
<td>0</td>
<td>1 amu</td>
</tr>
<tr>
<td>8. Electron</td>
<td>e(^-)</td>
<td>Surrounding the nucleus</td>
<td>1/1840</td>
<td>1 amu</td>
</tr>
</tbody>
</table>
Section 4.3 How Atoms Differ

In your textbook, read about atomic number.

For each statement below, write true or false.

1. The number of neutrons in an atom is referred to as its atomic number.  **F**
2. The periodic table is arranged by increasing atomic number.  **F**
3. Atomic number is equal to the number of electrons in an atom.  **T**
4. The number of protons in an atom identifies it as an atom of a particular element.  **T**
5. Most atoms have either a positive or a negative charge.  **T**

Answer the following questions.

6. Lead has an atomic number of 82. How many protons and electrons does lead have?  82\text{\ P}^+ \quad 82\text{\ e}^-

7. Oxygen has 8 electrons. How many protons does oxygen have?  8\text{\ P}^+

8. Zinc has 30 protons. What is its atomic number?  \text{30}

9. Astatine has 85 protons. What is its atomic number?  \text{85}

10. Rutherfordium has an atomic number of 104. How many protons and electrons does it have?  104\text{\ e}^-

11. Polonium has an atomic number of 84. How many protons and electrons does it have?  84\text{\ P}^+ \quad 84\text{\ e}^-

12. Nobelium has an atomic number of 102. How many protons and electrons does it have?  102\text{\ P}^+ \quad 102\text{\ e}^-

In your textbook, read about isotopes and mass number.

Determine the number of protons, electrons, and neutrons for each isotope described below.

13. An isotope has atomic number 19 and mass number 39.  19\text{\ P}^+ \quad 19\text{\ e}^- \quad 20\text{\ n}^0

14. An isotope has 14 electrons and a mass number of 28.  14\text{\ P}^+ \quad 14\text{\ e}^- \quad 14\text{\ n}^0

15. An isotope has 21 neutrons and a mass number of 40.  19\text{\ P} \quad 19\text{\ e} \quad 21\text{\ n}
16. An isotope has an atomic number 51 and a mass number 123.

\[ 51 \text{p}^+ \quad 51 \text{e}^- \quad 72 \text{a}^0 \]

Answer the following question.

17. Which of the isotopes in problems 13–16 are isotopes of the same element? Identify the element.

The 2 isotopes with atomic # 19 are both potassium.

Write each isotope below in symbolic notation. Use the periodic table to determine the atomic number of each isotope.

18. neon-22 \[ _{10}^{22} \text{Ne} \]
19. helium \[ _{2}^{4} \text{He} \]
20. cesium-133 \[ _{55}^{133} \text{Cs} \]
21. uranium-234 \[ _{92}^{234} \text{U} \]

Label the mass number and the atomic number on the following isotope notation.

22. \[ \text{mass} \quad 24 \rightarrow {}^{24}_{12} \text{Mg} \]
23. \[ \text{atomic} \quad 12 \rightarrow {}^{12}_{12} \text{Mg} \]

In your textbook, read about mass of individual atoms.

Circle the letter of the choice that best completes the statement.

24. The mass of an electron is
   a. smaller than the mass of a proton.
   b. smaller than the mass of a neutron.
   c. a tiny fraction of the mass of an atom.
   d. all of the above.

25. One atomic mass unit is
   a. \(1/12\) the mass of a carbon-12 atom.
   b. \(1/16\) the mass of an oxygen-16 atom.
   c. exactly the mass of one proton.
   d. approximately the mass of one proton plus one neutron.

26. The atomic mass of an atom is usually not a whole number because it accounts for
   a. only the relative abundance of the atom’s isotopes.
   b. only the mass of each of the atom’s isotopes.
   c. the mass of the atom’s electrons.
   d. both the relative abundance and the mass of each of the atom’s isotopes.
27.  76  
28.  Nb  190.2  
29.  amu  
30.  31.  
32.  O\text{\textsc{s}}  76p^+ 76e^-  
     Nb  41p^+ 41e^-  
32.  = (62.930)(0.6917) +  
     \phantom{=} \phantom{=}(64.928)(0.3085)  
     = 63.55 \text{amu}  
33.  Cu  
33.  = (34.969)(0.7577) +  
     \phantom{=} \phantom{=}(36.966)(0.2423)  
     = 35.46 \text{amu}  
34.  Cl  
