Includes:

Reproducible Student Pages

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- ✔ Chapter Tests
- ✔ Chapter Review

**HANDS-ON ACTIVITIES**
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- ✔ Laboratory Activities
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**MEETING INDIVIDUAL NEEDS**
- ✔ Directed Reading for Content Mastery
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Section Focus Transparency 2: Robin Adshead/CORBIS
Reproducible Student Pages

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Hands-On Activities
Mini LAB

Modeling the Nuclear Atom

Procedure
1. On a sheet of paper, draw a circle with a diameter equal to the width of the paper.

2. Small dots of paper in two colors will represent protons and neutrons. Using a dab of glue on each paper dot, make a model of the nucleus of the oxygen atom in the center of your circle. Oxygen has eight protons and eight neutrons.

Analysis
1. What particle is missing from your model of the oxygen atom?

2. How many of that missing particle should there be, and where should they be placed?
Mini LAB  Graphing Half-Life

Procedure
1. Thorium-234 has a half-life of 24 days. Fill the second column of the table below with the total number of days after each half-life.
2. Begin with a 64-g sample of thorium and calculate the mass remaining after each half-life.
3. Plot your data on the graph below. Note that Number of half-lives is on the x-axis and Mass remaining is on the y-axis.

Data and Observations

<table>
<thead>
<tr>
<th>Number of Half-lives</th>
<th>Days Passed</th>
<th>Mass Remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>64</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis
1. During which half-life does the most thorium decay?
2. How much thorium was left by day 144?
Lab Preview

Directions: Answer these questions before you begin the Lab.

1. Why do you think it is important not to take the lid off the box in this lab?

2. How can scientists use models like the one in this lab in research?

How do scientists make models of things they can’t see? They do experiments, gather as much information as possible, and then try to fit the information together into some kind of pattern and make inferences. From the data and inferences, they create a model that fits all their data. Often they find that they must revise their model when more data come to light.

Real-World Question

How can you determine the inside structure of a box?

Materials
sealed box
paper and pencil

Goals
- Observe the motion of a marble inside a closed box.
- Infer the structure of the divisions inside the box.

Procedure

1. Record the number of the box your teacher gives you. Don’t take the lid off the box or look inside.

2. Lift the box. Tilt the box. Gently shake it. Record all your observations in the Data and Observations section. Make a sketch of the way you think the marble in the box is rolling.

3. Use your observations to infer what the inside of the box looks like.

4. Compare your inferences with those of students who have the same box as you do. Then you might want to make more observations or revise your inferences.

5. When you have gathered all the information, sketch your model in the Data and Observations section.

6. Open your box and compare your model with the actual inside structure of the box.

Data and Observations
Communicating Your Data

Create a data table and set of instructions that would help another student systematically test a new sealed box. For more help, refer to the Science Skill Handbook.
Lab Preview
Directions: Answer these questions before you begin the Lab.

1. In this lab, how is radioactive decay determined?

2. In this lab, why is it important to know the original amount of material (represented by the pennies) to discuss half-life? Explain why or why not.

The decay rates of most radioactive isotopes range from milliseconds to billions of years. If you know the half-life of an isotope and the size of a sample of the isotope, can you predict how much will remain after a certain amount of time? Is it possible to predict when a specific atom will decay?

Real-World Question
How can you use pennies to create a model that will show the amount of a radioactive isotope remaining after specific numbers of half-lives?

Form a Hypothesis
Using the definition of the term half-life and pennies to represent atoms, write a hypothesis that shows how half-life can be used to predict how much of a radioactive isotope will remain after a certain number of half-lives.

Goals
- Model isotopes in a radioactive sample.
  For each half-life, determine the amount of change that occurs in the objects that represent the isotopes in the model.
- Design an experiment to test the usefulness of half-life in predicting how much radioactive material still remains after a specific number of half-lives.

Possible Materials
pennies
graph paper

test Your Hypothesis
Make a Plan
1. With your group, write the hypothesis statement.
2. Write down the steps of the procedure you will use to test your hypothesis. Assume that each penny represents an atom in a radioactive sample. Each coin that lands heads up after flipping has decayed.
3. List the materials you will need.
4. On a separate sheet of paper, make a data table with two columns. Label one Half-Life and the other Atoms Remaining.
5. Decide how you can use the pennies to represent the radioactive decay of an isotope.
6. Determine (a) what will represent one half-life in your model, and (b) how many half-lives you will investigate.
7. Decide (a) which variables your model will have, and (b) which variable will be represented on the y-axis of your graph and which will be represented on the x-axis.
Follow Your Plan
1. Make sure your teacher approves your plan and your data table before you start.
2. Carry out your plan and record your data carefully.

Analyze Your Data
1. The relationship among the starting number of pennies, the number of pennies remaining \( y \), and the number of half-lives \( x \) is shown in the following equation:

\[
y = \frac{\text{(starting number of pennies)}}{2^x}
\]

2. Graph this equation using a graphing calculator. Use your graph to find the number of pennies remaining after 2.5 half-lives.

3. Compare the results of your activity and your graph with those of other groups in your class.

Conclude and Apply
1. Is it possible to use your model to predict which individual atoms will decay during one half-life? Why or why not?

2. Can you predict the total number of atoms that will decay in one half-life? Explain.

Communicating Your Data
Display your data again using a bar graph. For more help, refer to the Science Skill Handbook.
Atoms—Smaller Than You Think!

Have you ever seen an atom? Unless you’ve been lucky enough to look through a very powerful microscope, you haven’t seen anything close in size to an atom. Matter is composed of atoms, and atoms are everywhere. You can’t see atoms or even molecules. They are too small. But even though you can’t see an atom with your own eyes, you can use other senses to detect the presence of some of the small molecules made from atoms. In this experiment, you will study the small size of vanilla molecules.

**Strategy**

You will predict what happens when drops of a liquid that is made up of small molecules are placed in a balloon.

You will observe some aspects of small molecules.

**Materials**

- rubber balloon
- dropper
- closet or locker
- vanilla extract (2 mL)

**Procedure**

1. Use a dropper to place 20 to 40 drops of vanilla extract into a rubber balloon. (See Figure 1)
2. Blow up the balloon, and tie it tightly.
3. Place the balloon in a small, enclosed area such as a closet or locker for at least 30 minutes.
4. What do you think will happen to the molecules of vanilla extract in the balloon? Record your predictions in the table in the Data and Observations section.
5. After 30 minutes, open the closet or locker. What did you observe? Record your observation in the Data and Observations section.

**Data and Observations**

<table>
<thead>
<tr>
<th>Predictions</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>2.</td>
</tr>
</tbody>
</table>
Laboratory Activity 1 (continued)

Questions and Conclusions

1. How do you explain the results of this experiment?

2. What can you infer from your results about the size of the vanilla molecules?

3. What does the fact that helium-filled balloons deflate tell you about the size of helium atoms?

4. Helium gas is made up only of helium atoms. Vanilla molecules have the formula C₈H₈O₃. Which do you think will leak more rapidly from equally inflated balloons—helium or vanilla? Use the size of the molecules to explain your answer.

Strategy Check

_____ Can you detect the presence of atoms and molecules that are very small with any sense but sight?

_____ Can you infer anything about the sizes of different molecules and atoms based on how they behave?
Elements as they occur in nature are mixtures of isotopes. All the isotopes of any given element have the same number of protons, but each isotope has a different number of neutrons. Most elements have more than one isotope. Therefore, the atomic masses of elements that are included in the periodic table are average atomic masses. In this exercise, you will use a model of isotopes to help you understand the concept of average atomic mass.

**Strategy**
You will model isotopes of two different elements using candy-coated peanuts and candy-coated chocolate in two colors.
You will determine the average mass of the two colors of candy-coated peanuts and candy-coated chocolate.
You will relate your results to the average atomic mass of elements.

**Materials**
4 red and 3 green candy-coated peanuts
4 red and 3 green candy-coated chocolates

**Procedure**
1. Group together four red candy-coated peanuts and two red candy-coated chocolates. The two different kinds of candy represent two isotopes of the same element.
2. Assume that a red peanut has a mass of 2 candy units, and a red chocolate has a mass of 1 candy unit. Calculate the average mass of the red candy as follows:
   a. Calculate the total mass of red peanuts by multiplying the number of red peanuts by the mass of one peanut candy.
   b. Calculate the total mass of red chocolates by multiplying the number of red chocolates by the mass of one chocolate candy.
   c. Add these two total masses together and divide by the total number of candies.
3. Repeat step 2 using three green peanuts and three green chocolates. Assume a green peanut has a mass of 4 units and a green chocolate has a mass of 3 units.
4. Record your calculations in the table in the Data and Observations section.

**Data and Observations**

<table>
<thead>
<tr>
<th></th>
<th>Mass of peanuts (number of candies × mass of 1 unit)</th>
<th>Mass of Chocolates (number of candies × mass of 1 unit)</th>
<th>Average mass (total mass / total number of candies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Questions and Conclusions

1. There were six red and six green candies. Why were their calculated average masses different?

2. Calculate the average mass of Y in a sample of element Y that contains 100 atoms of Y-12 and 10 atoms of Y-14.

3. Look at the atomic masses of elements in the periodic table. Notice that none of the atomic masses of naturally abundant elements are whole numbers. Use your candy model of atoms to explain this.

4. Uranium is an element used in most nuclear reactors. Its two major isotopes are U-235 and U-238. Look up the mass of uranium on the periodic table. Infer which isotope is the most common, and explain why you came to this conclusion.

5. Compare and contrast mass number and average atomic mass.

6. Hydrogen has three isotopes. The most common one, protium, has no neutrons. Deuterium, the second isotope, has one neutron. Tritium has two neutrons. Using this information, calculate the mass number of these isotopes.

Strategy Check

_____ Can you explain how candy-coated peanuts and candy-coated chocolate can be used as a model for isotopes?

_____ Are you able to find the average mass of an element?
Dalton proposed that an atom is a hard sphere that is the same throughout.

Thomson performed CRT experiments and discovered that atoms contain electrons. He proposed that an atom is made up of positive charge with negative electrons spread evenly throughout.

Rutherford’s experiment lead to his theory that all of the positive charge and most of the mass are concentrated in the nucleus.

Scientists working to determine what else could be in an atom to account for its mass proposed that the neutron was part of an atom as well.

An atom is made up of electrons, protons, and neutrons.

The electrons in an atom are the negatively charged particles.

The protons in an atom are the positively charged particles.

The neutrons in an atom are electrically neutral particles and have the same mass as the protons.
Meeting Individual Needs
**Overview**

**Inside the Atom**

**Directions:** Complete the concept map using the terms in the list below.

- nucleus
- positive protons
- negative electron cloud
- neutrons
- electrons

The regions of the atom are

1. [ ]
2. [ ]
3. [ ]
4. [ ]
5. [ ]
6. [ ]
7. [ ]

**Meeting Individual Needs**

**Directions:** Circle the term that best completes each sentence.

8. In a neutral atom, the number of protons always equals the number of (neutrons, electrons).

9. For any element, the number of neutrons in the nucleus of an atom can be calculated by subtracting the atomic number from the (mass number, number of natural isotopes).

10. A/An (alpha, beta) particle contains two protons and two neutrons.

11. (Transmutation, Electron transfer) occurs when one element changes into another through radioactive decay.
Section 1  •  Models of the Atom

Directions: Study the following diagram. Then label each part using the correct term from the list.

nucleus  proton  electron  neutron

1. ______________________________________________________
2. ______________________________________________________
3. ______________________________________________________
4. ______________________________________________________

Meeting Individual Needs

Directions: Answer the following questions on the lines provided.

5. Is the atom illustrated above more like Thomson’s model or Rutherford’s model? Why?

________________________________________________________________________
________________________________________________________________________

6. How did Thomson show that cathode rays are different from light?

________________________________________________________________________
________________________________________________________________________

7. In a cathode-ray tube, where do the particles originate? Towards what do they move?

________________________________________________________________________
________________________________________________________________________
Directions: Write the correct term for each definition in the spaces provided. The boxed letters should spell the words that describe the force that holds the nucleus together.

1. Atoms of the same element with different numbers of neutrons:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

2. Number equal to the number of protons in the nucleus:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \]

3. Number equal to the number of protons plus the number of neutrons:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

4. The average mass of the mixture of an element’s isotopes:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

5. The place where protons and neutrons are found:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

6. A researcher who uses carbon dating on ancient items:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

7. One element changing into another through radioactive decay:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

8. A radioactive element used in smoke detectors:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

9. The particle with two protons and two neutrons ejected during decay:
   \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

10. The time it takes for half a radioactive sample to decay:
    \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

11. A high-energy electron from the nucleus:
    \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

12. The release of nuclear particles and energy:
    \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

13. The gland that doctors image with iodine-131:
    \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \]

14. Write the boxed letters to reveal the force that holds the nucleus together.
    The \[ \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \text{____} \] force
Across

2. The release of nuclear particles and energy
4. A result of 2 across
7. An electron _____ is where 8 across will be found.
8. Negatively charged atomic particle
10. Average atomic ______
11. Positively charged atomic particle
12. Gold, iron, or sulfur

Down

1. The _____ of carbon-14 is 5,730 years.
3. Carbon-14 is an _____ of carbon.
5. Neutral particle in a nucleus
6. Hydrogen’s _____ number is 1.
9. The mass _____ of an isotope is the number of neutrons plus protons.
Las regiones del átomo son

1. que contiene dos clases de partículas
   - con una carga
   - con carga neutra

2. que contiene el(la)

3. el(la) que contiene dos clases de partículas

4. con una carga

5. con carga neutra

6. ____________

7. ____________

**Instrucciones:** Haz un círculo alrededor del término que mejor complete cada oración.

8. El número de protones siempre es igual al número de (neutrones, electrones) en un átomo neutro.

9. Para cualquier elemento, el número de neutrones en el núcleo de un átomo puede calcularse restando el número atómico del (número de masa, número de isótopos naturales).

10. Una partícula (alfa, beta) contiene dos protones y dos neutrones.

11. La (transmutación, transferencia electrónica) ocurre cuando un elemento se convierte en otro mediante la desintegración radiactiva.
Sección 1  ■ Modelos del átomo

Instrucciones: Estudia el siguiente diagrama. Rotula cada parte con el término correcto de la lista.

núcleo  protón  electrón  neutrón

1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________

Instrucciones: Contesta las siguientes preguntas en los espacios dados.

5. ¿Se parece más el átomo que se ilustra arriba al modelo de Thomson o al modelo de Rutherford?

______________________________
______________________________

6. ¿De qué forma mostró Thomson que los rayos catódicos son diferentes a la luz?

______________________________
______________________________

7. ¿En dónde se originan las partículas en un tubo de rayos catódicos? ¿Hacia dónde se mueven?

______________________________
______________________________

20  Dentro del átomo
Instrucciones: Escribe el término correcto para cada definición en el espacio dado. Las letras en las cajas deben deletrear la(s) palabra(s) que describe(n) la fuerza que mantiene unido el núcleo.

1. Número que es igual al número de protones en el núcleo:
   __ __ __ __ __ __ __ __ __ __ __ __ __

2. Electrón de alta energía del núcleo:
   __ __ __ __ __ __ __ __ __ __ __ __ __

3. Elemento radiactivo que se usa en los detectores de humo:
   __ __ __ __ __ __ __ __ __ __ __ __ __

4. Investigador que usa datación con carbono en objetos antiguos:
   __ __ __ __ __ __ __ __ __ __ __ __ __

5. El sitio en donde se encuentran los protones y neutrones:
   __ __ __ __ __ __ __ __ __ __ __ __ __

6. Masa promedio de una mezcla de los isótopos del elemento:
   __ __ __ __ __ __ __ __ __ __ __ __ __

7. Número que es igual al número de protones más el número de neutrones:
   __ __ __ __ __ __ __ __ __ __ __ __ __

8. Partícula con dos protones y dos neutrones que se expulsa durante la desintegración:
   __ __ __ __ __ __ __ __ __ __ __ __ __

9. Cambio de un elemento a otro durante la desintegración radiactiva:
   __ __ __ __ __ __ __ __ __ __ __ __ __

10. Tiempo que toma para que la mitad de un elemento radiactivo se desintegre:
    __ __ __ __ __ __ __ __ __ __ __ __ __

11. Liberación de partículas y energía nuclear:
    __ __ __ __ __ __ __ __ __ __ __ __ __

12. Átomos del mismo elemento con número diferente de neutrones:
    __ __ __ __ __ __ __ __ __ __ __ __ __

13. La glándula que los médicos observan con yodo-131:
    __ __ __ __ __ __ __ __ __ __ __ __ __

14. Escribe las letras de las cajas para revelar la fuerza que mantiene al núcleo unido. La __ __ __ __ __ __ __ __ __ __ __ __ __ fuerte
Instrucciones: Usa los siguientes términos para completar el crucigrama.

media vida  atómico  elemento  protón  desintegración radioactiva
electrón  isótopo  número  nube
transmutación  masa  neutrón

Horizontales
8. Liberación de partículas y energía nuclear.
9. Número 4 verticales se encuentra en el(la) ____ electrónica.
11. El carbono 14 es un(a) ____ del carbono.
12. ____ atómica promedio.

Verticales
1. Oro, hierro o azufre
2. Resultado del 1 horizontales.
3. Partícula atómica de carga negativa
5. Partícula neutra del núcleo.
6. (El)La ____ del carbono 14 es 5,730 años.
7. Partícula atómica de carga positiva
10. El número de _____ de un isótopo es el número de neutrones más el número de protones.
Models of the Atom

Directions: Identify each model of the atom.

1.  
2.  
3.  
4.  

Directions: Explain how each of the following scientists added to our knowledge of the atom.

5. Some Greek philosophers: ____________________________________________________________

6. John Dalton: ________________________________________________________________

7. William Crookes: ______________________________________________________________

8. J. J. Thomson: ________________________________________________________________

9. Ernest Rutherford: ______________________________________________________________

Directions: Answer the following questions on the lines provided.

10. According to the electron cloud model, do electrons orbit the nucleus like the Moon orbits Earth? Explain your answer.

________________________________________________________________________________

________________________________________________________________________________

11. What findings led Thomson to infer that particles that are smaller than atoms do exist?

________________________________________________________________________________

________________________________________________________________________________
The Nucleus

Directions: Answer the following questions on the lines provided.

1. What does the atomic number of an element refer to?

2. Define isotopes.

3. What is the strong nuclear force?

4. Name two types of transmutations.

5. Explain what happens during transmutation.

6. What is radioactive decay?

7. Describe an alpha particle.

8. Describe a beta particle.

9. What is meant by the half-life of a radioactive isotope?

10. Why are nuclear waste products a problem?

11. Why are tracer elements important?

Directions: Identify each statement as true or false. Rewrite the false statements to make them correct.

12. Radioactive isotopes used for medical purposes should have long half-lives.

13. Scientists can use particle accelerators to create new elements.

14. Archaeologists can estimate the age of any ancient artifact with carbon dating.

15. The half-life of a radioactive isotope decreases as the isotope decays.
The Bohr Model of the Atom

After Danish physicist Neils Bohr received a doctorate from the University of Copenhagen in 1911, he worked with J. J. Thomson, the British physicist who discovered the electron. By 1912, Bohr was working with Ernest Rutherford, who developed the nuclear theory of the atom. In 1913, Bohr published his own theory about the structure of the atom.

**Bohr’s Proposal**

Rutherford had shown that the nucleus of the atom is very dense, containing most of the mass of the atom. His experiments also showed the nucleus is very small by comparison to the space occupied by the electrons and that a lot of the space taken up by an atom is just that—empty space. Neils Bohr proposed that the electrons in this atomic space could occupy only very specific and separate energy levels as they swirl around the nucleus. He also thought that the farther away an electron is from the nucleus, the more energy the electron needs to stay in that level. Electrons usually are located in the lowest energy level available, which is called its ground state. Figure 1 shows the hydrogen atom in its ground state.

**Energy for the Jump**

Bohr suggested that when an electron absorbs enough energy—for example, when it is heated to a very high temperature—it moves to a higher energy level. Then the electron is in what is called an excited state. Figure 2 shows the hydrogen atom in an excited state.

When the energy source is removed, the electron drops back down to the ground state and gives off all the absorbed energy in one unit. These units are very specific amounts of energy. One of these units is called a quantum.

**Changing Energy Levels**

Bohr’s theory said an electron can’t exist between energy levels, like an elevator stuck between floors. If the electron has enough energy to move to another level, it does. If the electron doesn’t have quite enough energy, it remains in the lower level.

Bohr’s theory was not perfect. His calculations worked very well for the hydrogen atom, which has only one electron. But they didn’t work very well for bigger atoms. However, Bohr’s ideas helped other scientists develop what is known today as quantum mechanics, a field of physics that explains the structure and some of the behaviors of more complex atoms. This structure and behavior is explained by mathematics.

1. In what ways is the Bohr model of the atom different from the Rutherford model?

2. Explain why an atom absorbs or emits energy in very specific units.
Early in the twentieth century, German physicist Hans Geiger developed an instrument to detect ionizing radiation. The Geiger counter can detect gamma rays and alpha and beta particles. Prospectors can use Geiger counters to detect uranium and other radioactive elements. Scientists and other professionals use Geiger counters to detect the presence of radiation and to measure the level of the radiation. People who work with radiation can use a Geiger counter as a safety check.

**A Basic Design**

Geiger counters come in many different sizes and shapes, but the essential design is always the same. A typical Geiger counter consists of a cylindrical metal tube filled with an inert gas that can be readily ionized.

Stretched along this tube is a filament, or fine wire. The filament and the metal wall serve as electrodes. The filament is positively charged, and the wall is negatively charged.

An electric field exists between the filament and the wall of the tube. However, because the inert gas does not conduct electricity, an electric current is produced only when the inert gas is ionized. Radiation entering the chamber of the Geiger counter collides with the gas atoms, ionizing the gas and freeing electrons. The negatively charged electrons rush toward the positively charged filament. These electrons free more electrons, resulting in an avalanche of ions.

**The Sound of Electric Pulse**

The electrons spread out along the central filament and create an electric pulse. The electric pulse is counted by a meter. Even one particle results in a full pulse on the filament. Therefore, when the level of radiation increases, the clicking becomes louder and more frequent. The familiar static and clicking sounds identified with a Geiger counter result from the meter counting the pulses created by the electrons.

1. What are two important properties of the gas used in the chamber of a Geiger counter? Explain your answer.

2. What causes the atoms in the chamber to ionize?

3. How is radiation detected by a Geiger counter?
Inside the Atom

Section 1   Models of the Atom

A. Greek philosophers devised a theory of atoms, or tiny ___________________.

B. John Dalton combined the idea of ___________________ with the Greek theory of the atom.
   1. Matter is made up of _________________.
   2. Atoms ________________ be divided into smaller pieces.
   3. All atoms of an element are exactly _________________.
   4. Different elements are made of _________________ atoms.
   5. Dalton’s theory was tested by William Crookes and his _________________ tube experiment.

C. J. J. Thomson discovered negatively charged particles, _________________, which are a part of every atom.
   1. Thomson revised Dalton’s model to include a sphere with a ___________________ charge and negatively charged electrons spread evenly within the positive charge.
   2. The negatively charged electrons and the _________________ charge in the sphere neutralized each other.

D. Earnest Rutherford tested Thomson’s model, which was found to be an _________________ model of the atom.

E. An atomic model with a _________________ was developed.
   1. The positively charged _________________ is located in a very small space at the center of an atom.
   2. Most of an atom is _________________ occupied by nearly massless electrons.
   3. Electrically neutral particles, _________________, are also located in the nucleus.
   4. The number of electrons _________________ the number of protons in an atom.

F. The _________________ model explains the unpredictable wave behavior of electrons, which could be anywhere in the area surrounding the nucleus.
Section 2  The Nucleus

A. __________________ number—number of protons in the nucleus of an atom
   1. Isotopes of an atom have the same number of __________________ but different numbers of neutrons.
   2. ______________ number is the number of neutrons plus the number of protons.
   3. Average atomic mass—the average mass of the mixture of an element’s ______________
   4. The strong nuclear ______________ holds tightly packed protons together in a nucleus.

B. Radioactive ______________ occurs when an atom releases nuclear particles and energy.
   1. When a proton is released, one element changes into another, a process called ____________________.
   2. ______________ particle
      a. Two protons and two neutrons are released during transmutation.
      b. Atomic number decreases.
   3. ______________ particle
      a. A high-energy electron from the nucleus is released with energy when an unstable neutron splits into an electron and a proton.
      b. Atomic number increases by one.

C. ______________ of a radioactive isotope is the amount of time it takes for half the sample to decay.
   1. Half-lives range in ______________ from fractions of a second to billions of years.
   2. ______________ dating is used to determine the age of artifacts and fossils.
   3. Radioactive ______________ must be disposed of carefully to avoid harming people and the environment.

D. ______________ elements are made in labs by smashing atomic particles into a target element.
   1. Radioactive isotopes from artificial transmutation are called tracer elements and can be used for ______________ purposes.
   2. Tracer elements are also used to study the ______________ impact of pesticides and fertilizers and to locate water resources.
Assessment
Part A. Vocabulary Review

Directions: Match each term in Column II with the correct definition in Column I. Write the letter of the correct term in the blank at the left.

<table>
<thead>
<tr>
<th>Column I</th>
<th>Column II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. matter that is made up of only one kind of atom</td>
<td>a. neutron</td>
</tr>
<tr>
<td>2. a negatively charged particle that is part of every kind of matter</td>
<td>b. mass number</td>
</tr>
<tr>
<td>3. a positively charged particle that is present in the nucleus of all</td>
<td>c. atomic number</td>
</tr>
<tr>
<td>atoms</td>
<td>d. element</td>
</tr>
<tr>
<td>4. uncharged particle in the nucleus of an atom</td>
<td>e. beta particle</td>
</tr>
<tr>
<td>5. region surrounding the nucleus in which the electrons move about</td>
<td>f. electron cloud</td>
</tr>
<tr>
<td>6. the number of protons in the nucleus of an atom of an element</td>
<td>g. electron</td>
</tr>
<tr>
<td>7. atoms of the same element that have different numbers of neutrons</td>
<td>h. half-life</td>
</tr>
<tr>
<td>8. the number of neutrons plus protons in the nucleus of an atom</td>
<td>i. isotopes</td>
</tr>
<tr>
<td>9. the mass of the mixture of the isotopes for an element</td>
<td>j. transmutation</td>
</tr>
<tr>
<td>10. the release of nuclear particles and energy</td>
<td>k. alpha particle</td>
</tr>
<tr>
<td>11. the changing of one element into another element through radioactive</td>
<td>l. proton</td>
</tr>
<tr>
<td>decay</td>
<td>m. radioactive decay</td>
</tr>
<tr>
<td>12. particle consisting of two protons and two neutrons</td>
<td>n. average atomic mass</td>
</tr>
<tr>
<td>13. a high-energy electron that comes from the nucleus, not from the</td>
<td></td>
</tr>
<tr>
<td>electron cloud</td>
<td></td>
</tr>
<tr>
<td>14. the amount of time required for half a sample of a radioactive</td>
<td></td>
</tr>
<tr>
<td>isotope to decay</td>
<td></td>
</tr>
</tbody>
</table>

Assessment
Chapter Review (continued)

Directions: Complete the following sentences using the terms listed below. Some terms may not be used.

atoms anode predictable cathode sphere
cloud random tracer elements archaeology chemistry

15. The study of matter is called ____________________.
16. Different elements are made up of different kinds of ____________________.
17. A(n) ____________________ is an electrode that has a positive charge.
18. A(n) ____________________ is an electrode that has a negative charge.
19. An electron cloud is shaped like a(n) ____________________ with the nucleus at its center.
20. Radioactive decay is a(n) ____________________ process.
21. Isotopes called ____________________ are used to diagnose disease and to study environmental conditions.

Part B. Concept Review

Directions: Study the following diagram. Then label each part using the correct terms from the list.

electron electron cloud neutron nucleus proton

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

Directions: Complete each sentence by underlining the best of the three choices in parentheses.
6. The Greeks named what they believed to be the tiniest particle of matter a(n) (proton, atom, cell).
7. An element is made up of only one kind of (isotope, atom, particle).
8. Research using (television, atomic bombs, cathode rays) led scientists to believe that the atom could be broken down into smaller particles.
9. A(n) (electron, proton, neutron) is electrically neutral.
10. An atomic nucleus is often most stable if the number of protons is (equal to, greater than, less than) the number of neutrons.
11. Atoms of the same element always have the same number of (neutrons, electrons, protons).
12. To find the number of neutrons in an isotope, start with the mass number and (add the atomic number, subtract the atomic number, multiply by two).
13. If you have 16 g of a substance that has a half-life of 3 days, after 12 days you will have (8, 1, 0) g of the substance remaining.
Transparency Activities
Who’s there?

Have you ever tried to guess someone’s identity without looking? The girl on the right is using her sense of touch to identify one of her friends. The girl must rely on senses other than sight to solve her mystery. Sometimes, science also investigates things that require more than sight to understand.

1. Identify all the human senses.
2. Name some things you know exist but can’t see. How do you know they exist?
Atomic Dive

This modern submarine gets its power from reactions that split atoms. Heat from these reactions is used to make the steam that drives the sub’s turbines. This type of submarine can go a long time without refueling.

1. How else might people use the type of power that fuels this submarine?
2. Why might this type of power be a particular advantage for submarines?
3. What’s the one life necessity that a submarine must supply its crew that a surface vessel does not?
Rutherford's Experiment

Most of the particles pass through the foil with little or no deflection.

A few of the particles ricochet back toward the source.

Source of positively charged particles

Positively charged particle beam

Gold foil

Detector screen

Transparency Activities
Teaching Transparency Activity (continued)

1. Explain Thomson’s model of the atom.

2. Why did Rutherford think Thomson’s cookie dough atom would deflect only a few light particles?

3. Rutherford disagreed with Thomson’s model, that an atom’s mass and charge could be found in one area. Where did Rutherford’s model put these components?

4. The data, however, didn’t match Rutherford’s model either, as the mass of atoms was at least twice what he predicted. What particle was discovered that explained this difference in mass?

5. Why can’t the exact locations of electrons be pinpointed?
Inside the Atom

Directions: Carefully review the diagram and answer the following questions.

1. According to the diagram, the nucleus contains ___.
   A. Electrons and Neutrons
   B. Protons and Electrons
   C. Neutrons and Protons
   D. only Protons

2. If the mass number is the sum of protons and neutrons, what is the mass number of the atom pictured?
   F. 6
   G. 7
   H. 12
   J. 13

3. Isotopes are atoms of the same element that have different numbers of neutrons. If a neutron was added to this diagram, which isotope would it be?
   A. Carbon-12
   B. Carbon-13
   C. Carbon-14
   D. Carbon-7