

Features of Active Chemistry


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The Periodic Table

Scenario


Every time you say you like or don't like something, you are putting it into a category. You have probably developed categories for many things in your life. You may have categories for food you eat for breakfast, as opposed to dinner, or for clothes you wear to school, as opposed to at home. Can you imagine what your life would be like if nothing were sorted into categories? What if you went shopping in a supermarket that displayed milk next to shoe polish, next to oranges, next to oatmeal, next to hams, next to orange juice, next to detergent? Where would you look for yogurt, shoelaces, corn flakes, ground beef, lemonade, and soap?

That kind of supermarket display pretty much describes the state of chemistry in the mid-19th century. By then chemists had identified and isolated a large number of chemical elements, but they needed a way to sort them into categories—much as a supermarket groups milk with yogurt, shoe polish with shoe laces, oatmeal with corn flakes, ham with ground beef, orange juice with lemonade, and detergent with soap.



Like similar items in a supermarket, some chemical elements were recognized to share similar chemical properties. The first chemist to arrange these elements successfully into a pattern according to their properties was the Russian, Dimitri Mendeleev.

One of the things Mendeleev did was to write down everything that was known about each element on a small card. Then he moved the cards around until he got an arrangement that showed the groups of elements with similar properties.



Dimitri Mendeleev

In Mendeleev's time the periodic table was developed as a way to arrange elements according to their chemical behavior. Surprisingly, it then revealed information about the structure of the atoms of those elements as well.

By writing the properties of the elements onto separate cards and arranging them, Mendeleev created a puzzle, and he solved that puzzle when he arranged the first version of what is now known as the Periodic Table of the Elements. The table was independently created at the same time by the German, Julius Lothar Meyer.

Chapter Challenge

Your challenge in this chapter is to develop a game related to Mendeleev's Periodic Table of the Elements.

How the game is played, whether on a table, with cards, on a computer, or with equipment that only you might choose, is up to you. You might even choose to emphasize some aspects of the periodic table over others, or to focus on some types of information presented by the table rather than others. However, you need to keep in mind the criteria you and your teacher establish.

Criteria

How will your game be graded? What qualities should a good game have? Discuss these issues in small groups and with your class. You may decide that some or all of the following qualities should be graded:

- how well the game shows your understanding of the periodic table;
- how well the game enables players to learn about the periodic table;
- how interesting the game is to play;
- how long the game takes to play;
- whether the game is sequential or can be continued.

Once you have determined the list of qualities for evaluating the game, you and your class should also decide how many points should be given for each criterion. Make sure that you understand all the criteria as well as you can before you begin. Your teacher may provide you with a sample rubric to help you get started.

1. Scenario

Each *Active Chemistry* chapter opens with an engaging scenario. Students from diverse backgrounds and localities have been interviewed in order to find situations which are not only realistic but meaningful to the high school population. The scenarios (only a paragraph or two in length) set the stage for the **Chapter Challenge** that immediately follows. Many teachers choose to read the scenario aloud to the class as a way of introducing the new chapter.

2. Chapter Challenge

The **Chapter Challenge** is the heart and soul of *Active Chemistry*. It provides a purpose for all of the work that will follow. The

challenges provide the rationale for learning. One of the common complaints teachers hear from students is, “Why am I learning this?” In *Active Chemistry*, students do not raise this question. Similarly, teachers do not have to answer, “Because someday it will be useful to you.” The complaint is avoided because on Day One of the chapter students are presented with a challenge that, in essence, becomes their job for the next few weeks.


In *The Periodic Table*, Chapter 7, students are asked to develop a game based on Mendeleev's Periodic Table. Students must use their decision-making skills to decide on the type of game to develop and the mode in

which it is delivered, but their knowledge of the elements is critical to success! Therefore, each chapter activity builds their bank of knowledge about the elements and atoms.

In Chapter 8, *Cool Chemistry Show*, students must present sensational science to fourth- and fifth-graders. The challenge is to make chemical concepts interesting enough to hold young children's interest and easy for them to understand. In order to be successful, students must first complete each activity to build their own understanding of chemical and physical changes, chemical names and formulas, chemical equations, and reactions. In addition to preparing lessons for their younger audience, students must include demonstrations, written summaries, and integration of safety rules.

The beauty of the challenges lies in the variety of tasks and opportunities for students of different talents and skills to excel. Students who express themselves artistically will have an opportunity to shine in some challenges, while the student who can design and build may be the group leader in another challenge. Some challenges have a major component devoted to writing while others require oral or visual presentations. All challenges require the demonstration of a solid understanding of chemistry.

The challenges are not contrived situations. For example, designers of games, both board games and electronic, must be able to think in an organized, logical way. The relevance of the challenge in Chapter 8 is apparent to all, as teachers must be able to convey knowledge in an interesting and understandable manner to their students every day!



- adherence to assigned time limits
- showmanship
- creativity
- clarity
- organization
- appeal
- written summary
- directions for experiment
- explanation of chemistry
- appropriateness for an elementary school teacher with limited chemistry background
- statements concerning safety needs

The class, as a whole, is responsible for putting on this Cool Chemistry Show. You will need to coordinate your selection of presentations to provide a show that addresses a variety of chemistry concepts in an entertaining and informative manner.

Criteria

How will your involvement in the Cool Chemistry Show be graded? What qualities should a good presentation have? Discuss these issues in small groups and with your class. You may decide that some or all of the following qualities of your presentation should be graded:

- Chemistry content
 - accuracy
 - meets teacher needs (fourth or fifth grade)
 - number of concepts addressed
- Demonstration
 - carefully planned
 - safety
 - explanation (age-appropriate)

Once your class has determined the list of criteria for judging the presentations, you should also decide how many points should be given for each criterion. Determining grading criteria in advance will help you focus your time and effort on the various aspects of the presentation. How many points should be assigned to the content and how many should be assigned to the actual presentation? Will each high school student be involved in only one presentation, or more? For each criterion, you should decide on how excellence is defined and how it compares to a satisfactory effort.


Since you will be working with other students in small groups, you will need to determine grading criteria that reward each individual in the group for his or her contribution and also reward the group for the final presentation. You should discuss different strategies and choose the one that is best suited to your situation. Your teacher may provide you with a sample rubric to help you get started.

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3. Criteria


In creating *Active Chemistry*, we originally thought that the generation of the challenge was good enough. Upon reflection, we soon realized that criteria for success must also be included. When students agree to the matrix by which they will be measured, the research has shown that the students will perform better and achieve more. In the simplest situation of cleaning a lab room, the teacher may simply state, "Please clean up the lab." The results are often a minimal cleanup. If the teacher begins by asking, "What does a clean lab room look like?" and students and teacher jointly list the attributes of a clean lab room (i.e., no paper on the floor, all beakers put away, all materials on the back of the lab tables, all power supplies unplugged and all water removed), the students respond differently and the cleanup is better. When students are asked to include chemical principles in an explanation, the students should know whether the expectation is for three chemical principles or five.

The discussion of grading criteria and the creation of a grading rubric is a crucial ingredient for student success. *Active Chemistry* requires a class discussion, after the introduction of the challenge, about the grading criteria. How much is required? What does an “A” presentation look like? Should creativity be weighed more than delivery? The criteria can be visited again at the end of the chapter, but at this point it provides a clarity to the challenge and the expectation level that the students should set for themselves.


Active Chemistry The Periodic Table

Activity 1

Organizing a Store



GOALS

In this activity you will:

- Plan the arrangement of the items for sale in a store.
- Analyze trends in the arrangement of the store.
- Relate the arrangement of items in the store to the arrangement of elements in the periodic table.

What Do You Think?

Some supermarkets now sell books, flowers, and prescription drugs in addition to eggs, meat, and cereal.

- How many different items do you think that a supermarket has in its inventory?

Record your ideas about this question in your *Active Chemistry* log. Be prepared to discuss your responses with your small group and the class.

Investigate

1. Suppose that you decided to go into the business of opening and running a supermarket grocery store. In your group, brainstorm a list of between 50 and 100 items you would sell at your supermarket.

A member of your group should volunteer to record the items suggested by all members of the group. Everyone, including the person serving as recorder, should participate in suggesting items to be sold.

a) Make a map showing the locations of all of the items in your store. Give some thought to what will be at the

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4. What Do You Think?

During the past few years much has been written about a constructivist approach to learning. Videos of Harvard graduates, in caps and gowns, show that the students are not able to explain correctly why it is colder in the winter than it is in the summer. These students have previously answered these questions correctly in fourth grade, in middle


school, and then again in high school. How else would they have gotten into Harvard? We believe that they never internalized the logic and understanding of the seasons. One reason for this problem is that they were never confronted by what they did believe, and were never adequately shown why they should give up that belief system. Certainly, it is worth writing down a “book’s perfect answer” on a test to secure a good grade, but to actually believe requires a more thorough examination of competing explanations.

The best way to ascertain a student’s prior understanding is through extensive interviewing. Much of the research literature in this area includes the results of these interviews. In a classroom this one-on-one dialogue is rarely possible. The **What Do You Think?** question introduces each activity in a way in which to elicit prior understandings. It gives students an opportunity to verbalize what they think about elements, atoms, or reactions before they embark on an activity. The brief discussion of the range of answers brings the students a little closer in touch with that part of his/her brain which understands elements, atoms, or reactions. The **What Do You Think?** question is not intended to produce a correct answer or a discussion of the features of the questions. It is not intended to bring closure. The activity which follows will provide that discussion as experimental results are analyzed. The **What Do You Think?** question should take no more than a few minutes of class time. It is the lead into the chemistry investigation.

Students should be strongly encouraged to write their responses to the questions in their logs, to ensure that they have in fact addressed their prior conceptions. After students have discussed their responses in their small groups, activate a class discussion. Ask students to volunteer other students’ answers which they found interesting. This

Activity 4 Are Atoms Indivisible?

Activity 4 Are Atoms Indivisible?



GOALS

In this activity you will:

- Observe the behavior of a cathode ray in the presence of a magnet.
- Discuss Thomson's conclusions from 1897 about cathode rays.
- Simulate an experiment from 1911 by Rutherford in which he learned more about the structure of atoms.
- Organize your understanding of some of the different particles that comprise matter.

What Do You Think?

Ever since Democritus from ancient Greece hypothesized the existence of atoms, a major question was how atoms of different elements were different.

- If you could observe a single atom of gold and a single atom of lead, how do you think they would be different? How could they have something in common?


Record your ideas about these questions in your *Active Chemistry* log. Be prepared to discuss your responses with your small group and the class.

Investigate

1. Your teacher will demonstrate the behavior of what were called cathode rays a hundred years ago. They were called cathode rays because they were emitted from the negative terminal, or cathode of what was known as a cathode-ray tube, a forerunner of the television or the computer monitor tube.

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- a) What happens to the path of the cathode rays when a horseshoe magnet is placed near the tube? Record your observation in your *Active Chemistry* log.
- b) Record what you think will happen to the path of the cathode rays when the orientation of the horseshoe magnet is reversed.
- c) Observe the path of the cathode rays as your teacher reverses the magnet. Record what does happen.

2. Magnets exert a force on moving electrically charged particles. The effect of the magnet on the cathode rays therefore shows that these rays are moving electrically charged particles. Cathode rays, which have a negative electric charge, are made up of electrons. In 1897, Joseph John (J. J.) Thomson showed that identical rays (electrons) were emitted from the cathode of a cathode-ray tube, regardless of the metal of which the cathode was made.

Discovery of electrons emerging from the atoms of the cathode gave scientists new information about the atom. The atom is not indivisible. It has internal parts, one of which is the electron.

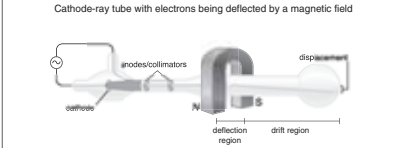
a) In a sentence or two, describe the relationship between cathode rays, the electron, and the structure of atoms.

3. In order to investigate the other components of an atom, you will take part in the following simulation, similar to the game *Battleship*. You will work with a partner for this activity.

You and your classmate should each construct a grid of squares, 8 by 10. Without letting your classmate see your grid, color in a section of ten squares. The squares must touch each other. To make the simulation relatively simple, begin with a fairly compact design. This shape (colored region) represents your target.

You and your partner will try to guess the shape of each other's targets by sending "missiles" onto any of the 80 squares in this array. For the purpose of this description, designate one person to be Player X and the other person to be Player Y. To begin, Player X will tell Player Y the destination (number and letter) of

Cathode-ray tube with electrons being deflected by a magnetic field



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may encourage students to exchange ideas without the fear of personally giving a “wrong” answer.

5. Investigate

Active Chemistry is a hands-on, minds-on curriculum. Students do chemistry; they do not read about doing chemistry. Each activity has instructions for each part of the investigation. Students are reminded that data, hypotheses, and conclusions should be recorded in their log or laboratory manual.

Activities are the opportunity for students to garner the knowledge that they will need to complete the **Chapter Challenge**. Students will understand the chemical principles involved because they have investigated it. In *Active Chemistry*, if a student is asked, “How do you know?” the response is, “Because I did an experiment!”


Recognizing that many students know how to read, but do not like reading, background

information is provided within the context of the activity. Students have demonstrated that they will read when the information is required for them to continue with their exploration.

Occasionally, the activity will require the entire class to participate in a large, single demonstration simultaneously. The teacher, on other occasions, may decide that a specific activity is best done as a demonstration. This would be appropriate if there is limited equipment for that one activity, or the facilities are not available. Viewing demonstrations on an ongoing basis, however, is not what *Active Chemistry* is about.

Icons throughout the activities alert students to safety issues that should be given attention. Students are reminded of all safety rules throughout the program. An overview of safety rules for the chemistry classroom, as well as a safety contract, is available starting on page xx of this Unit.

Most of the **Investigate** activities require between one and two class periods. Considering current trends in class scheduling, there are so many time structures that it is difficult to predict how *Active Chemistry* will best fit your schedule. The other impact on time is the achievement and preparation level of the students. For example, in a given activity students may be required to complete a graph of their data. This is considered one small part of the activity. If the students have never been exposed to graphing, this could require a two-period lesson to teach the basics of graphing with suitable practice in interpretation. *Active Chemistry* is accessible to all students. The teacher is in the best position to make accommodations in time reflecting the needs of the students.


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ChemTalk

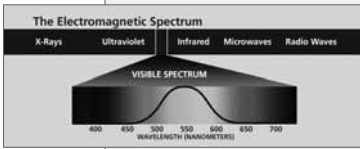
BOHR'S MODEL OF AN ATOM
The Electromagnetic Spectrum

Visible light is only one part of the **electromagnetic spectrum**. You've probably heard of some of the other parts including ultraviolet, infrared, x-rays, gamma rays, microwaves, and radio waves. As you demonstrated in calculations using Bohr's model, the light from some of the transitions is in the ultraviolet. Infrared light is also emitted as the electron jumps from E_4 to E_3 and E_5 to E_3 and other higher energy levels.

Many people do not think of radio waves as being light waves, but they are part of the electromagnetic spectrum. The problem is that you can only see a very small part of the electromagnetic spectrum. Often, you hear radio announcers say that they are broadcasting at a certain **frequency**. Your FM radio dial may have MHz (megahertz) printed on the side. This tells you that the numbers correspond to frequencies in units of MHz or 10^6 Hz. Frequency tells you the number of cycles or waves that are being produced per second. The unit for frequency is a hertz (Hz). $1 \text{ Hz} = 1 \text{ cycle/s} = 1 \text{ s}^{-1}$. Normally, frequency is read as per second and the cycles are dropped from the terminology.

Wavelength (λ), where λ is the Greek letter *lambda*, is the distance from crest to crest of a wave. All light waves travel at the same speed. The speed of electromagnetic radiation is constant and it is called the speed of light (c), $c = 2.998 \times 10^8 \text{ m/s}$ or $3.00 \times 10^8 \text{ m/s}$. From this information you can calculate the frequency of light of a given wavelength. The equation that is used for this is:

$$f = \frac{c}{\lambda}$$



The Electromagnetic Spectrum

X-Rays Ultraviolet Infrared Microwaves Radio Waves

VISIBLE SPECTRUM

400 450 500 550 600 650 700

WAVELENGTH (NANOMETERS)

Chem Words

electromagnetic spectrum: the complete spectrum of electromagnetic radiation, such as radio waves, microwaves, infrared, visible, ultraviolet, x-rays, and gamma rays

frequency: the number of waves per second or cycles per second or hertz (Hz)


wavelength: the distance measured from crest to crest of one complete wave or cycle

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6. ChemTalk

Sometimes it is difficult for students to make the conceptual leap from doing an activity to connecting the ideas into a chemical principle. Indeed, if you consider the theory of multiple intelligences, some students grasp concepts more easily by reading. **ChemTalk** summarizes the chemistry principles and includes chemical formulas and equations where appropriate. It presents students with text, illustrations, and photographs that provide greater insight into the chemistry concepts presented. If sample problems or important laws are integral to the lesson they can be found in **ChemTalk**.

Activity 5 The Chemical Behavior of Atoms



As an example, if the wavelength is 434.2 nm, then the frequency is:

$$f = \frac{2.998 \times 10^8 \text{ m/s}}{434.2 \times 10^{-9} \text{ m}}$$

$$= 6.905 \times 10^{14} \text{ cycles/s or } 6.905 \times 10^{14} \text{ Hz.}$$

As you go across the electromagnetic spectrum you should note that the wavelength continues to get smaller as the frequency increases. Also, you should understand that the energy of the spectrum increases as you go from radio waves to x-rays or gamma rays. Max Planck, a German physicist, found that the energy of a wavelength could be calculated. The equation that he developed was based on measuring the change in energy from one level to another level like you did in the **Investigate** section. The equation he developed is

$$E = hf,$$


where h is Planck's constant and is $6.63 \times 10^{-34} \text{ J} \cdot \text{s}$ and f is the frequency.

The corresponding energy of the red light above would be:

$$E = hf$$

$$= (6.63 \times 10^{-34} \text{ J} \cdot \text{s}) (4.567 \times 10^{14} \text{ Hz})$$

$$= 3.03 \times 10^{-19} \text{ J.}$$



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pound of hydrogen to form water. Accurate modern experiments give eight pounds to one. We will use modern values rather than historical ones to avoid confusion. Dalton reported that five pounds of nitrogen reacted with one pound of hydrogen to form ammonia. He also reported that seven pounds of oxygen reacted with five pounds of nitrogen to form a compound he called nitrous gas.

In 1809, Joseph Gay-Lussac reported that the hydrogen reacting with oxygen to form water occupied twice as much volume as the oxygen. He also noted that the hydrogen reacting with nitrogen to form ammonia occupied three times as much volume as the nitrogen. Furthermore, he found that equal volumes of nitrogen and oxygen reacted to form nitrous gas (now known as nitric oxide or nitrogen monoxide, NO).

Gay-Lussac's data was inconsistent with Dalton's assumption that water, ammonia, and nitrous gas are formed from one atom of each of the combining elements. This inconsistency was subsequently resolved by Amadeo Avogadro, who furthered the understanding of the correct chemical formulas and atomic masses.

Chem Words

atomic mass unit (amu): a unit of mass defined as one-twelfth of the mass of a carbon-12 atom
 atomic mass: atomic mass is determined by the mass of the protons and neutrons of the atom
 law of definite proportions: the composition of a pure substance is always the same or the elements of the compound always combine in the same proportion by mass

Relative Mass of Atoms

Eventually, chemists determined a scale of relative masses of atoms through the systematic study of chemical reactions. By measuring the masses of two elements reacting with each other and knowing the formula for the compound that was formed, the relative mass of the two elements was determined. In this way, chemists were able to determine, for example, that one element has twice the mass of a second element. Relative mass does not tell you the exact mass measured in kilograms. It does provide a relative scale. Comparison of many reactions resulted in a scale of relative masses. Atoms of carbon were found to have a mass 12 times greater than the mass of hydrogen atoms, whereas oxygen atoms were found to have a mass 16 times greater than the mass of hydrogen. The units for this scale are called **atomic mass units**, defined in such a way that the mass of one type of carbon (carbon-12) is exactly 12 atomic mass units. The average mass of an atom of a given element in atomic mass units is known as the **atomic mass**. Atoms of hydrogen have an atomic mass of one unit. In addition to the physical and chemical properties of

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Activity 2 Elements and Their Properties

Reflecting on the Activity and the Challenge

In this activity you learned not only the definition of a chemical element but also some of the properties of chemical elements. Measuring these properties not only enabled Mendeleev to place the elements in his periodic table but also allowed other chemists to identify the elements. You have tried to sort the cards of elements in the same way that Mendeleev did. Perhaps your periodic table game can have sorting cards as one part of the strategy.

Chemistry to Go

1. Make a list of three more physical properties of a chemical element that you could observe.
2. Make a list of three more chemical properties of a chemical element that you could measure.
3. Why did you want the metals to be clean or polished before you tested them for electrical conductivity?
4. What criteria did you use to differentiate metals from nonmetals in this investigation?
 - a) Is this a valid statement of a trend you saw: as the color of the element becomes darker, the element is less metallic? Support your assessment of this statement with evidence that you observed in your investigation.
 - b) Is this a valid statement of a trend you saw: the elements react with hydrochloric acid more as you move down a list of the elements listed in alphabetical order? Support your assessment of this statement with evidence that you observed in your investigation.

Preparing for the Chapter Challenge

Prepare a set of index cards for each of the elements with which you are familiar. Record as many properties of each element you know on the card.

Use your observations in the following activities and any research you complete on your own to add information to each card.

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7. Chem Words

Science has a language of its own. In order to fully participate in science students need to have an understanding of this language. When there is vocabulary that is critical to the understanding of an activity or reading it is highlighted in the text. These words are also pulled outside the text area and redefined. Such support helps students understand the process of learning as they note important ideas within the text.

8. Reflecting on the Activity and the Challenge

At the close of each activity, the student is often so involved with the completion of the single experiment that the larger context of the investigation is lost. **Reflecting on the Activity and the Challenge** is the opportunity for students to place the new insights and information into the context of the chapter and the **Chapter Challenge**. If the **Chapter Challenge** is considered a completed picture, each activity is a jigsaw piece.

By completing enough of the **Investigate** activities, the students will be able to fit the jigsaw pieces together and complete the challenge. This summary section ensures that the students do not forget about the larger context and continue their personal momentum toward completion of the challenge.





Active Chemistry Cool Chemistry Show

Chem Words
oxidation number: a number assigned to an element in a compound designating the number of electrons the element has lost, gained, or shared in forming that compound



charges" are used as a type of bookkeeping and are called **oxidation numbers**. In both ionic compounds and molecular compounds the atoms achieve a stable state, similar to the noble gases.

Reflecting on the Activity and the Challenge

In this activity you have learned how to write the formulas for many compounds and how to name some compounds. You have also investigated both ionic and molecular compounds. As you prepare your presentation for your Cool Chemistry Show, you will want to include your knowledge of formulas, the names of compounds,

and the different kinds of compounds. Remember that you will be providing the teacher with an explanation of why you included certain demonstrations, and you will also want to include explanations that are grade-appropriate. Think about how much information you will need to provide for each demonstration.

Chemistry to Go

- Write the chemical formula and name for the compound formed when the following pairs of elements are combined:
 - a) sodium and bromine
 - b) potassium and sulfur
 - c) magnesium and chlorine
 - d) cesium and iodine
 - e) aluminum and oxygen



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- The red light you observed in the hydrogen spectrum produced a $\lambda = 656.5$ nm. The energy of the red light was 3.02×10^{-19} J. How many times greater is this value when compared to the energy value that you found for the microwave energy?



Inquiring Further

Balmer, Lyman, and Paschen series

In this activity, you learned that the visible light emitted by the hydrogen lamp resulted when an electron moved from a higher energy level to the second lowest energy level in Bohr's scheme. This series of visible spectral lines is said to comprise the Balmer series. What do you think happens when an electron in a hydrogen atom moves

from a higher energy level to the lowest level? This series is known as the Lyman series (ultraviolet light). What if a transition from a higher energy level leads to an electron in the third lowest energy level in Bohr's scheme? How do these energy levels compare with visible light? This series is known as the Paschen series (infrared light).

9. Chemistry to Go

This section provides additional questions and problems that can be completed outside of class. Some of the problems are applications of the principles involved in the preceding activity. Others are replication of the work in the Investigate activity. Still others provide an opportunity to transfer the results of the investigation to the context of the Chapter Challenge. Chemistry to Go provides a means by which students can be working on the larger Chapter Challenge in smaller chunks during the chapter.

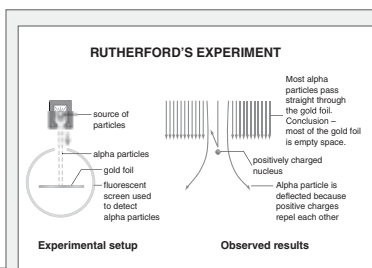
10. Inquiring Further

The outcome of good science instruction should be the ability of students to transfer that knowledge to a different problem or task. Inquiring Further exercises gives students the opportunity to stretch their thinking beyond the textbook and classroom setting. This can be accomplished with a provocative question or problem to solve. Students can put into practice the technique, approaches, and knowledge they have

acquired by completing the activity and expand upon it to gain new information. The Inquiring Further exercises can be assigned as independent study or as a class extension to the investigation.



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Checking Up

- What is an electron?
- Thomson's model of an atom is sometimes referred to as the "plum-pudding" model. (A plum pudding is a heavy pudding with raisins mixed into it.) Explain why this is an appropriate comparison.
- Why was Rutherford surprised that some alpha particles bounced back from the gold foil?
- What is the nucleus of an atom?

A Physics Connection

What was responsible for the wide-angle scattering of the alpha particles and their bouncing back? The force between the positive nucleus and the positive alpha particle is the coulomb force. Positive charges repel one another according to the coulomb force law.

$$F = \frac{kq_1q_2}{d^2}$$

where k is Coulomb's constant ($k = 9.0 \times 10^9 \text{ N m}^2/\text{C}^2$), q is the charge in coulombs, and d is the distance between the charges.

The closer the alpha particle gets to the nucleus, the larger the force and the larger the deflection of the alpha particle.

11. Checking Up

If students are expected to take ownership of the learning process, then they need to have a way to monitor their own understanding. Embedded in the curriculum of *Active Chemistry* are questions that may be used by students for self-assessment. By answering the questions they can determine the degree to which they comprehend the information available and if they need to revisit some concepts for better understanding.

Active Chemistry Cool Chemistry Show

c) Green leaves turn orange, yellow, and red in the fall.
 d) Green bananas become yellow.
 e) Butter melts on a hot summer day.

2. Think back to a recent lunch or dinner. Describe two physical and two chemical changes that were involved in the meal and explain why you think each was a physical or chemical change.

3. Write a paragraph describing a common activity (such as making a cake or driving a car). Underline the physical changes (use one line) and chemical changes (use two lines) taking place within the activity. Select and describe an activity that is sure to have at least two physical changes and two chemical changes.

4. The following information is obtained for the element aluminum. Identify which are physical (use one line) and which are chemical (use two lines) properties.

Aluminum is a shiny silver metal and melts at 660°C. When a strip of aluminum is placed in hydrochloric acid, hydrogen gas is released. The density of aluminum is 2.70 g/cm³. When polished aluminum is exposed to oxygen over a period of time it forms aluminum oxide (Al₂O₃) on the surface of the metal.

5. How would you determine whether a clear solution in a beaker is saturated sugar water or just water? Remember, you do not taste samples in the laboratory.

Preparing for the Chapter Challenge

Describe how you would demonstrate the difference between a physical and chemical change in a “cool” way.

Inquiring Further

Factors affecting solubility and the rate of dissolving

Understanding the factors that affect how quickly a solute dissolves in a solvent is important in many practical applications in manufacturing. Design an investigation to determine the factors that affect solubility. Consider the following:

- nature of the solute and solvent;
- temperature;
- agitation (stirring or shaking);
- surface area (for example, try using a sugar cube, granulated sugar, and icing sugar);
- pressure of gases.

Remember that your investigation must be controlled, if your results are to be reliable. What will be your independent and what will be your dependent variables?

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12. Preparing for the Chapter Challenge

Each activity is a step toward completing the Chapter Challenge. In order to keep students engaged in the challenge, **Preparing for the Chapter Challenge** activities maintain the connection to the overarching goal. It provides students with suggestions for organizing their work and prompts them to build on their knowledge as they move through the chapter.

The Periodic Table Assessment

Your Chapter Challenge is to develop a game related to Mendeleev's Periodic Table of the Elements.

The game should be interesting, entertaining and informative. It should demonstrate your understanding of the periodic table while it helps other students learn about the periodic table. When people begin your game, they may have no knowledge of chemistry or the periodic table. After they complete the game, they should be able to report on chemistry principles which are reflected in the periodic table.

You can begin work on the Chapter Challenge by reviewing the important features of the periodic table that you want to include in your game. Choose a small section of the periodic table and list what you know about each element including its atomic number, atomic mass, chemical properties, electron configuration, nuclear structure and where and why it is placed where it is in the periodic table. Next to each of these items, you may wish to describe how we know some of these details (e.g., describe the Rutherford scattering experiment for evidence of the nucleus, Law of Definite Proportions for evidence of atoms). You should review the nine activities in the chapter to add to your list. You should pay particular attention to the section **Reflecting on the Activity and the Challenge**. You should also compare your list with that given in the **Chemistry You Learned** summary.

You now have to create the game which will highlight the chemistry

principles that you have investigated in the past few weeks. There are a wide variety of games. There are traditional board games like Monopoly, Parcheesi, Clue and Risk. There are card games like gin rummy, hearts, solitaire, poker and bridge. There are TV games like *Jeopardy*, *Wheel of Fortune* and *The Price is Right*. There are video games like *SimCity*, *PacMan* and *Space Invaders*.

There are also word games like crossword puzzles and anagrams. You have lots of experience with many different kinds of games. The first hurdle for your team will be to decide on the type of game that you will use as the format for communicating your knowledge of the periodic table. Your game should not merely be a periodic table test. It should be an entertaining approach to learning about the periodic table as well as displaying knowledge.

Once you decide and agree upon a game format, you will have to generate a set of rules. These rules will include whether people work individually or in groups, how one earns points or wins, how to get help during the game and suggested strategies for the game.

After the rules of the game are set, you must integrate your expert knowledge of the periodic table into the game. How will people playing the game learn that the atomic number corresponds to the number of protons and electrons in the neutral atom? How will players learn that isotopes of chlorine affect the stated mass? How will players get credit for

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13. Chapter Assessment

The Chapter Assessment is the return to the Chapter Challenge and Criteria. The students are ready to complete the challenge. They are able to view the challenge with a clarity that has emerged from the completion of the **Investigate** activities of the chapter. Students are able to review the chapter as they discuss the synthesis of the information into the required context of the challenge. The students should have some class time to work together to complete the challenge and to present their project. In many chemistry courses, all students are expected to converge on the same solution. In *Active Chemistry*, each group is expected to have a unique solution. All solutions must have correct chemistry, but there is ample room for creativity on the students' part. This is one of the features that captures the imagination of students who have often previously chosen not to enroll in chemistry classes.



Active Chemistry Movie Special Effects

limitations and still be entertaining, interesting and appealing.

Once you have agreed on the script and the special effects, each team member can be assigned one of the remaining responsibilities. Who will write the detailed instructions on how to complete the procedure? Who will demonstrate the special effect? Who will write the explanation of the chemistry behind the demonstration? Writing the procedure will require a closer review of the specific activity that you are using. Writing an explanation of the chemistry will also require you to carefully review the activity with particular emphasis on the Chem Talk section.

If there are 4 members of the team, each team member may be responsible for one special effect and its procedure, demonstration and chemistry. Alternatively, one team member may be writing all of the procedures while another team

member writes all of the chemistry explanations. However you divide the work, it will be important for each team member to share the contribution with the entire group before the due date. Be sure to leave some time to provide feedback and improve upon each part before the final project is due.

You should practice your demonstration before the presentation. Does every team member know their part? Is every team member aware of the time limitations? Are safety issues noted and taken into account? Review all of the criteria listed at the beginning of the chapter and the grading criteria agreed to by your teacher and class. Create a checklist and perform a final review of your checklist. Grade yourself before your presentation to insure that your team is heading for a great grade.

Chemistry You Learned

Elements and symbols	Physical properties of elements and compounds	Temperature	Properties of metals and nonmetals
Chemical formulas	Phase changes and properties of matter	Solutions	Polymers
Compounds	Sublimation	Suspensions	Hydrocarbons
Electrolysis and synthesis of water	Kinetic energy and Potential energy	Colloids	Organic compounds vs. inorganic compounds
Chemical properties of elements and compounds	Freezing points and Boiling points	Composites	
		Tyndall Effect	
		Density of liquids, solids and gases	
		Instrumental measurements (precision and accuracy)	

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14. Chemistry You Learned

This small section at the end of the chapter provides a list of chemistry concepts which were studied in the context of the Investigate activities. It provides students with a sense of accomplishment and serves as a quick review of all that was learned during the preceding weeks.

15. Chemistry At Work

This section highlights an individual whose work or hobby is illustrative of the Chapter Challenge. Chemistry At Work speaks to the authenticity of the challenge. This profile illustrates how knowledge of chemistry is important and valuable in different walks of life.

Chemistry at Work

Marc Pollack

President, Filix FX



"Everyone talks about 'Movie Magic,'" says Marc Pollack, president of the prestigious Hollywood special effects company Filix FX. "So I guess that makes me a magician." But Pollack is clearly more comedian than magician. The "magic" he creates for movies like *Blackhawk Down*, *Men In Black* and *Cast Away*, in addition to scores of television commercials, museum installments and Las Vegas casinos, is the product not of mysterious hocus-pocus but rather fundamental principles of science. "One of the most important aspects of our work," he continues, "is to push the limits of how chemicals are designed to be used." Among other things, Pollack and his crew at Filix FX use vacuum-forming thermoplastics to make tin-based silicon molds for everything from prehistoric creatures to futuristic robots. Through a combination of trial and error experimentation and traditional research science, they've perfected the process. "Silicon is what we call an R.T.V.," Pollack explains. "That stands for room temperature vulcanization. So depending on the type and amount of catalyst we use, the mold will cure at different rates and with slightly differing properties." By manipulating the ratio of silicon to catalysts they can make strong, realistic molds in the most efficient way possible. "Increasing the amount of catalyst will speed up the curing process but too much catalyst will shorten the life of the mold," he says. "Every job is different so

determining that balance is one of our many challenges."

Pollack, who is now a master in the art of using chemicals like silicon, polypropylene, urethane and urethane elastomers, is not a chemist by trade. He actually graduated from film school at SUNY Purchase in the hopes of becoming "the next Steven Spielberg." Then, through a twist of fate, he became a special effects nut and eventually founded Filix FX in 1990. "Now," Pollack says, "Spielberg may one day come to me." Special effects — Pollack creates both mechanical and physical — is an industry in a constant state of transformation. "The industry is always trying new stuff and that's exciting," Pollack says. "For instance, someone just developed a great water-based breakaway glass for stunts called Smash Glass. It's similar to fiberglass without the dangerous elements associated with that material and can be made to break into either large chunks or tiny little pieces. I can't wait to get my hands on it and break it over someone's head. That's part of my job these days and I love it."

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