Name: ____ Period: ____ Date: ______

Required Summer Assignment: LHS Honors Chemistry

Teachers

If you need help at any point while working on this packet, you may contact the Honors Chemistry teachers using the methods below:

Mr. Little **Email:** MrLittleScience@yahoo.com
Twitter: @MrLittleScience

Mrs. Hoffman **Email:** KHoffman@basdschools.org

Rationale

Honors Chemistry is designed to introduce you to the structure of substances as well as the changes that they undergo. Prior to entering the classroom, this course requires a basic understanding and review of several physical science topics presented in earlier courses. To best prepare you for the rigors of this course, you are required to use critical thinking to analyze data, interpret information, and generate conclusions.

Due Date

This completed packet is due to your Honors Chemistry Teacher on the **FIRST DAY** of school REGARDLESS of when you are scheduled for the course. This assignment will be collected and checked for completeness. During class we will discuss and review any questions or concerns regarding this assignment.

Assignments

The summer work is composed of three parts. Each part has tasks that correspond to the reading or activity for that section. Be sure to complete all sections! ***__YOU ONLY NEED TO PRINT PAGES 1-9… the rest can be viewed!!!__***

- **Part One: Recycling Factory Density Activity**

  -Read the introductory information and problem scenario
  -Complete the chart

- **Part Two: Substances Affect on Boiling Point Lab Experiment**

  -Make a graph using the given data
  -Analyze the results of the experiment to complete all post-experiment questions

- **Part Three: A Tale of Two Chemicals**

  -Read the attached article and presentation
  -Respond to all article questions

Note: Please be aware that some of the material found in these assignments is a review of topics covered in your high school science and math courses. Some of the material presented may be challenging or require you to think critically so do your BEST to work through ALL questions and use the given materials to help you!

BASD Drop/Add Policy
The following guidelines exist for all other schedule changes requested after August 1st:

1) A schedule change request form must be completed by the student and parent. Forms are available in the Counseling Office or the teacher.

2) Schedule changes will be considered for valid educational reasons only. Schedule changes will not be made to accommodate requests for lateral moves within the same subject area or teacher preference.

3) The counselor and assigned teacher will review the schedule change requests.

4) Quarter courses (half semester courses) will not be dropped after the first 5 days of class.

5) Full semester courses will not be dropped after the first 15 days of class.

6) All students must maintain a full schedule for the entire year.

7) Level changes will not be considered unless the student has a 75% or lower in the course.

Withdrawals from a course will not become part of the student record if the course is dropped within the first 15 days of a semester class and within the first 5 days of a quarter course (half semester course). A “W” (Withdrew) will be recorded after those days but prior to the end of the first quarter. Either a “WP” (Withdraw Passing) or “WF” (Withdraw Failing) will be recorded if the course is dropped after the first marking period, indicating the student’s progress at the time of withdrawal.

A course change must be based upon academic considerations, and be facilitated by a conference/plan developed by the student, parent, teacher, and counselor/grade level administrator to support student success. This plan will require tutoring, completion of all required work to date, and a sincere demonstration of effort and ability by the student prior to dropping a course or level of course for all classes in English, Social Studies, Math, Science and Foreign Language.

IN THE SCIENCE DEPARTMENT, WE TAKE ACADEMIC INTEGRITY SERIOUSLY, AND WILL EXPECT THE SAME FROM YOU. ACADEMIC MISCONDUCT IS ANY ATTEMPT BY A STUDENT TO GAIN AN ACADEMIC ADVANTAGE, OR TO HELP OTHERS DO SO, THROUGH DISHONEST ACTIONS. ALL WORK IS EXPECTED TO BE YOUR OWN. DO NOT COMPLETE THESE ASSIGNMENTS WITH THE HELP OF ANYONE ELSE. ANY SUSPICION OF ACADEMIC MISCONDUCT WILL RESULT IN A ZERO ON THE ENTIRE ASSIGNMENT.

PART ONE: Recycling Factory Density Activity

Directions
Read the following background information about density. This information will help you complete the density activity that follows.

Background Information
Density is the mass of a substance compared to its volume. It may help to think of density as the amount of stuff in a certain amount of space. Something crammed with a lot of stuff (mass) in its space (volume) has a high density. Conversely, something with only a little stuff in the same amount of space has a lower density. Density is measured in g/mL or g/cm^3.

Elements and compounds have their own unique density. For example, the density of water is 1.00 g/cm^3. Why do certain substances float when placed in water? The answer has to do with density. Objects that have a density less than water will float, while objects with a greater density than the liquid will sink. Knowing the density of a material can be valuable when trying to separate a mixture of various substances.

Problem
Suppose that Mr. Little is the new owner of the Canes Recycling Factory and he is looking for business.

An official from the city of Bethlehem, Mrs. Hoffman, tells him that the city has a dump truck full of recycled materials that must be separated and they will pay him $10,000 if he can do it. Unfortunately, the job is going to be more difficult than originally thought because someone has ground all of the materials into a fine powder, making it impossible to separate them by hand.

Fortunately, Mrs. Hoffman knows what materials are in the truck and their densities:

Material	Density (g/cm^3)
Aluminum soda cans	2.7
Steel cans	5.7
Milk jugs	0.95
Soda bottles	1.4

Materials Available
In the Canes Recycling Factory, the following materials are available to use:

- A long conveyor belt
- A large tank that can be filled with water
- Another large tank labeled "Concentrated sugar water, density = 1.5 g/cm^3"
- Several powerful magnets hanging above the conveyor belt
- Several nets for skimming the tanks and scooping material from the bottoms

Task

As an employee of the factory, you are picked to find a way to separate the four recycled materials. You will need to create a numbered step-by-step outline of each material removed along with a detailed explanation of how/why the material will be removed before the city will pay any money. Use your knowledge of density and ALL of the available materials to help you separate the mixture. Record your procedure and detailed reasoning in the space provided below.

Procedure

Complete the chart given below. Be sure to include the substance removed and a DETAILED explanation of how/why the material will be removed in the order and methods you determined.

Substance Removed	How / Why
1)	
2)	
3)	
4)	

PART TWO: Substances Affect on Boiling Point Lab Experiment

Directions
Interpret the following data from a lab experiment. Use this information to help you create a graph and complete the analysis questions that follow.

Lab Data

Table 1. Table displaying mass of sugar dissolved in water and boiling point temperature for the water.

Mass of Sugar (g)	Boiling Point Temperature ($^{\circ}$C)
50.0	100.5
100.0	101.0
150.0	101.8
200.0	102.2
250.0	102.6
300.0	103.1

Graph
Make a graph of the data above using the blank template below. Be sure to include a title, both axis labels with units, accurate increments, and draw a line through your data points.

Post-Experiment Analysis

1) Using the graph you created, what is the relationship between increasing the mass of the sugar and the boiling point of the water?

2) Calculate the slope of the line you made using the following equation: y_2-y_1 / x_2-x_1.

3) Extend your line back to the y-axis and determine the value of the y-intercept with correct units (*Note: this value should NOT be zero).

4) Write the equation of the line (y = mx + b) using your value for slope and y-intercept.

5) Using the equation of your line, determine the temperature that the water will boil if 500.0 grams of sugar are added.

6) Using the equation of your line, what would be the mass of sugar added if the boiling point was found to be 101.4°C?

7) When boiling pasta, salt is often added to the water to add to the flavor. Explain in detail how this will impact the time it takes for the water to boil.

8) Adding substances to water will decrease the point at which water will freeze. Provide an example of how this property is useful in a real world situation.

PART THREE:
A Tale of Two Chemicals

Directions

Read Chapter 1 from our Glencoe textbook. You will find the chapter at the end of this assignment. Then, view the attached presentation as well, which includes additional information. Finally, answer the questions below. You can also view the following videos that go along with the attached presentation:

-Ozone Formation (slide 11): https://www.youtube.com/watch?v=eLKrNV1NzUo
-Molina-Rowland Model (slide 23):
http://www.glencoe.com/sites/common_assets/science/cmc/cim/animations/ch1_1.swf
-Ozone Destruction (slide 25): https://www.youtube.com/watch?v=gHonfdKGwqc
-The Current Model (slide 29): https://www.youtube.com/watch?v=qUfVMogIdr8

Questions

1) How does the ozone layer form?

2) Why is it important?

3) If 3 oxygen atoms (O) are needed to form 1 molecule of ozone (O_3), how many ozone molecules can be formed from 6 oxygen atoms? From 9 oxygen atoms? From 27?

4) Why were chlorofluorocarbons developed?

5) Why were chlorofluorocarbons thought to be safe?

6) Why did the concentration of chlorofluorocarbons in the atmosphere increase?

7) Why was it important for Dobson's data to be confirmed by satellite photos?

8) **Figure 6** in Chapter 1 of the Glencoe text shows that the CFC level was measured at about 272 *ppt* (parts per thousand) in 1995. Because *percent* means "parts per hundred," what percent is represented by 272 ppt? What would the concentration of CFCs be in *ppb* (parts per billion)? Show your work below.

9) Good scientific models can be tested and used to make predictions. According to Molina and Rowland's model, what would happen to the amount of ozone in the atmosphere as the level of CFCs increased?

10) According to Molina and Rowland's model, which gas concentration would be considered the independent variable: CFCs or ozone?

11) Why do we consider Molina and Rowland's model a *theory* rather than a *law*?

12) Is the term "ozone hole" an accurate description of ozone levels above Antarctica? Justify your response.

13) Is the "ozone hole" no longer a concern? Justify your response.

Data Analysis

The National Oceanic and Atmospheric Administration (NOAA) continue to monitor the concentration of ozone in the stratosphere over Antarctica. Use the graph of NOAA data from the final slide in the presentation (also present in color on the NEXT PAGE for easy viewing) to answer questions 14 through 18.

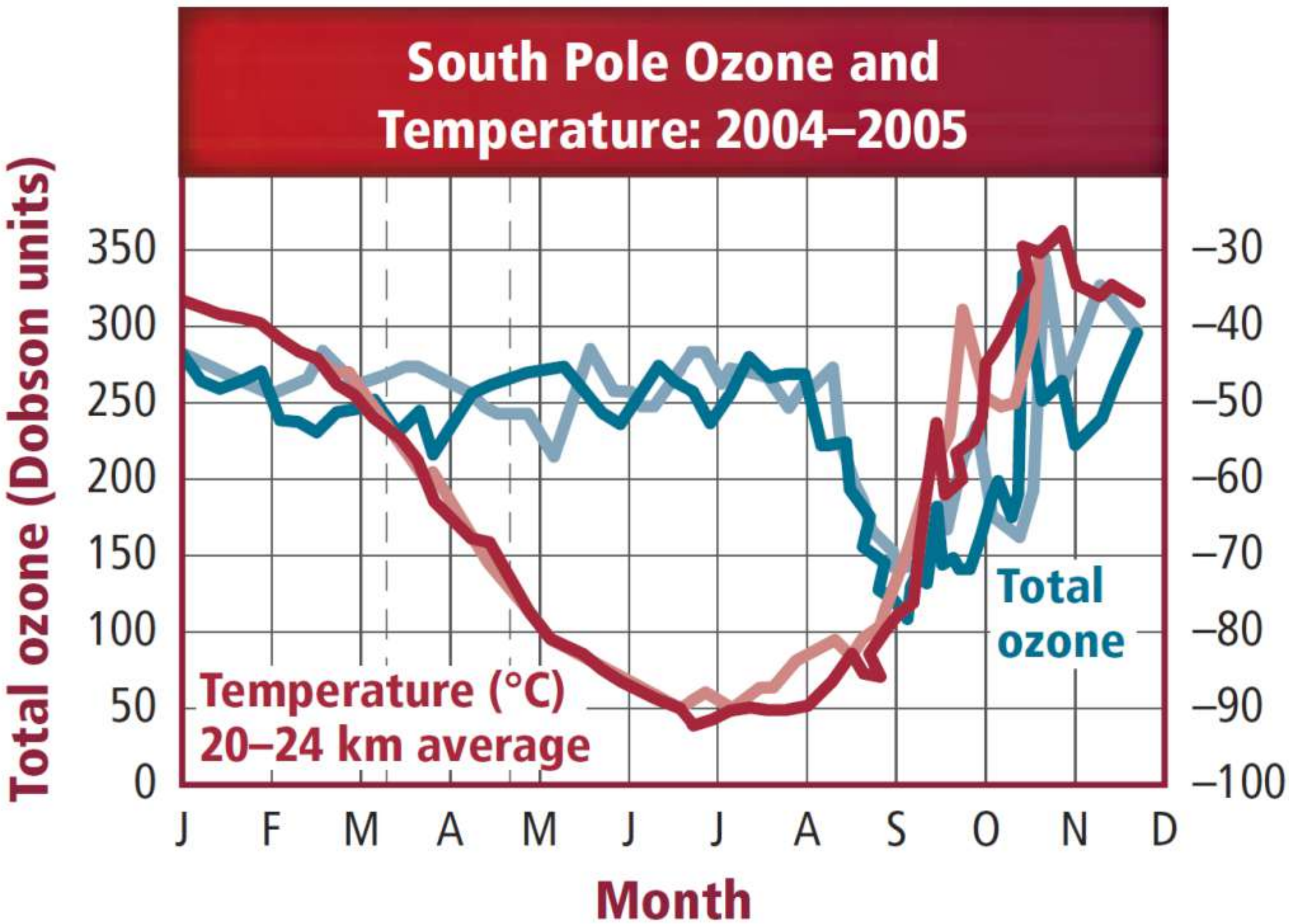
14) Describe the **overall** yearly trend in ozone concentration, according to the graph.

15) Describe the **overall** yearly trend in average temperature, according to the graph.

16) How does average temperature affect ozone concentration? NOTE: This effect is not necessarily immediate.

17) Therefore, how does average temperature affect ozone depletion by CFCs?

18) How do you think climate change will affect the ozone levels over Antarctica? Explain.


South Pole Ozone and
Temperature: 2004–2005
Total ozone (Dobson units)
350
300
250
200
150
100
50
0
−30
−40
−50
−60
−70
−80
−90
−100
Temperature (°C)
Total
ozone
Temperature (°C)
20–24 km average
J
F
M
A
M
J
J
A
S
O
N
D
Month

CHAPTER 1

Introduction to Chemistry

BIGIDEA Chemistry is a science that is central to our lives.

SECTIONS

1 A Story of Two Substances

2 Chemistry and Matter

3 Scientific Methods

4 Scientific Research

LaunchLAB

iLab Station

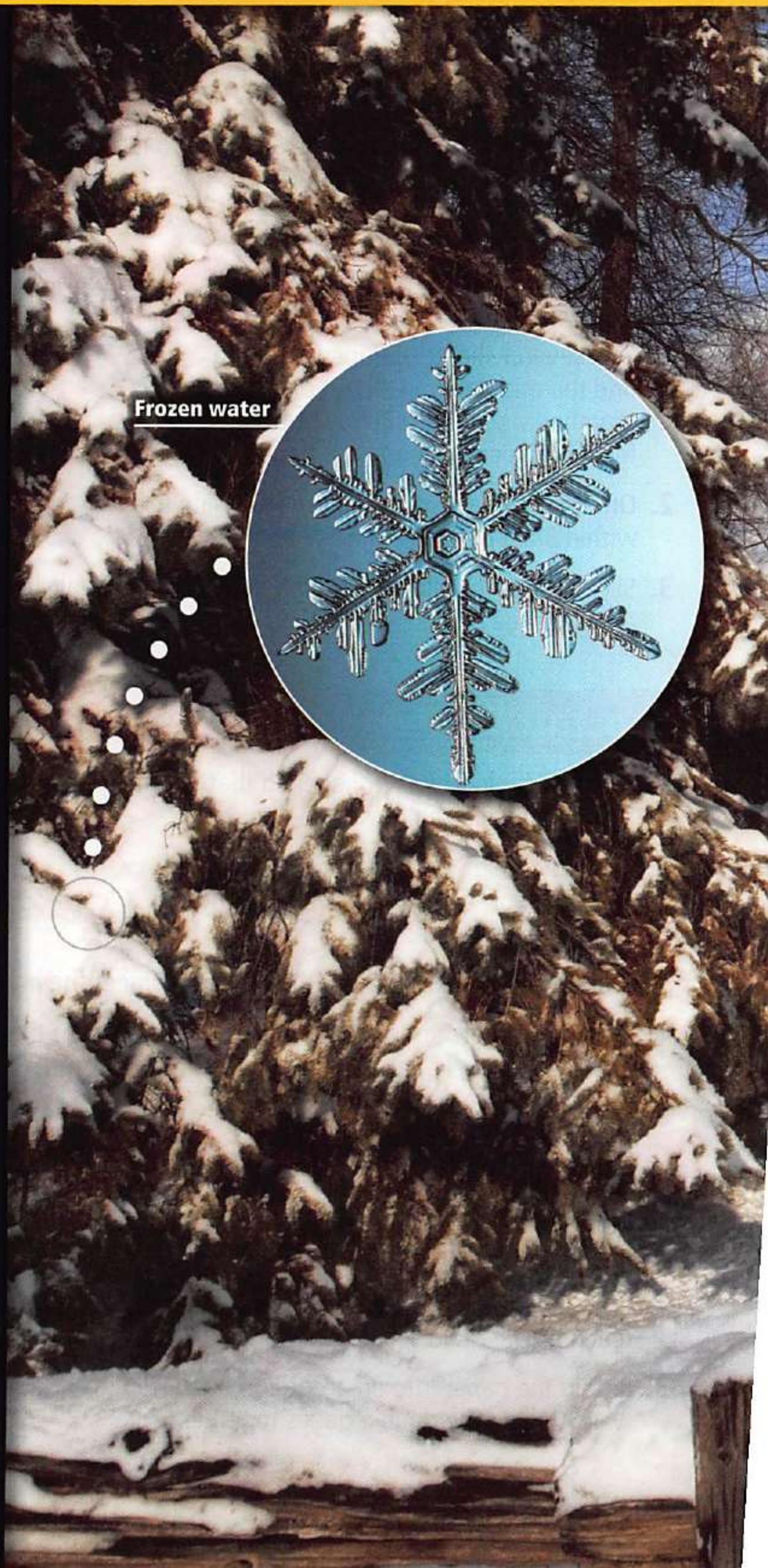
Where did the mass go?

When an object burns, the mass of what remains is less than the original object. What happens to the mass of the object?

FOLDABLES® Study Organizer

Scientific Methods

Make a concept-map book. Label the tabs as follows: *Observation, Hypothesis, Experiments,* and *Conclusion.* Use it to summarize what you learn about scientific methods.



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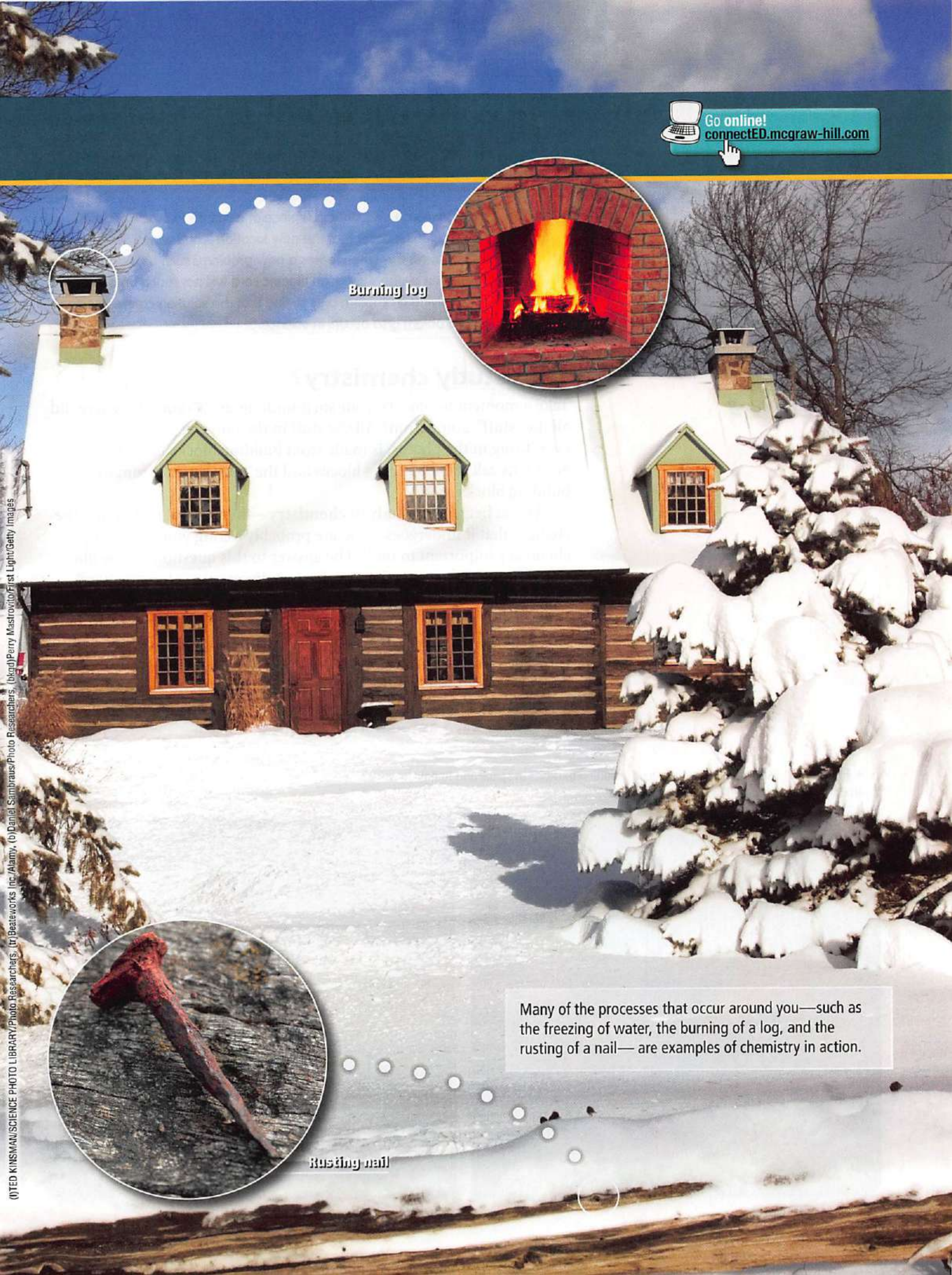


Many of the processes that occur around you—such as the freezing of water, the burning of a log, and the rusting of a nail— are examples of chemistry in action.

SECTION 1

A Story of Two Substances

MAINIDEA Chemistry is the study of everything around us.

Essential Questions

- What is a substance?
- How does ozone form and why is it important?
- What are chlorofluorocarbons and how do they get into the atmosphere?

Review Vocabulary

matter: anything that has mass and takes up space

New Vocabulary

chemistry
substance

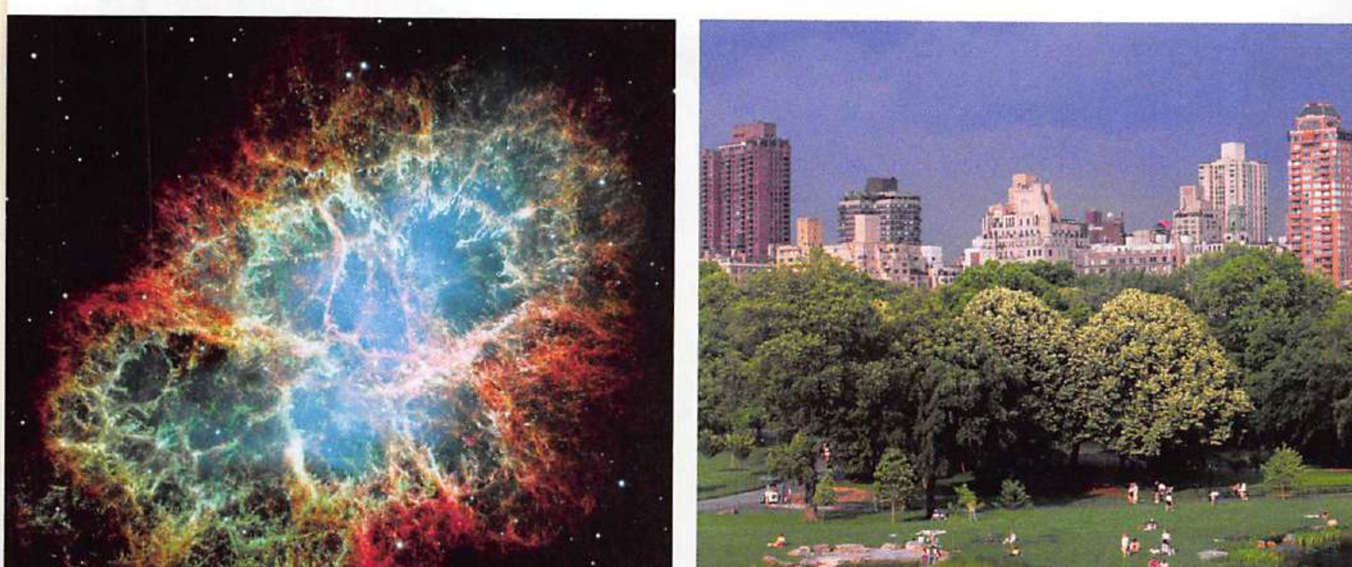
CHEM 4 YOU **Have you ever moved a piece of furniture to a new location, only to discover that the new location won't work? Sometimes, moving furniture creates a new problem, such as a door will not open all the way or an electric cord will not reach an outlet. Solving a problem only to find that the solution creates a new problem also occurs in science.**

Why study chemistry?

Take a moment to observe your surroundings and **Figure 1.** Where did all the "stuff" come from? All the stuff in the universe, including everything in the photos, is made from building blocks formed in stars. Scientists call these building blocks and the "stuff" made from these building blocks *matter.*

As you begin your study of **chemistry**—the study of matter and the changes that it undergoes—you are probably asking yourself, "Why is chemistry important to me?" The answer to this question can be illustrated by real-life events that involve two discoveries. One discovery involves something that you probably use every day—refrigeration. If you go to school in an air-conditioned building or if you protect your food from spoilage by using a refrigerator, this discovery is important to you. The other discovery involves energy from the Sun. Because you eat food and spend time outdoors, this discovery is also important to you. These two seemingly unrelated discoveries became intertwined in an unexpected way—as you will soon learn.

Figure 1 Everything in the universe, including particles in space and things around you, is composed of matter.



(l)STScI/NASA/CORBIS, (r)Atlantide Phototravel/CORBIS

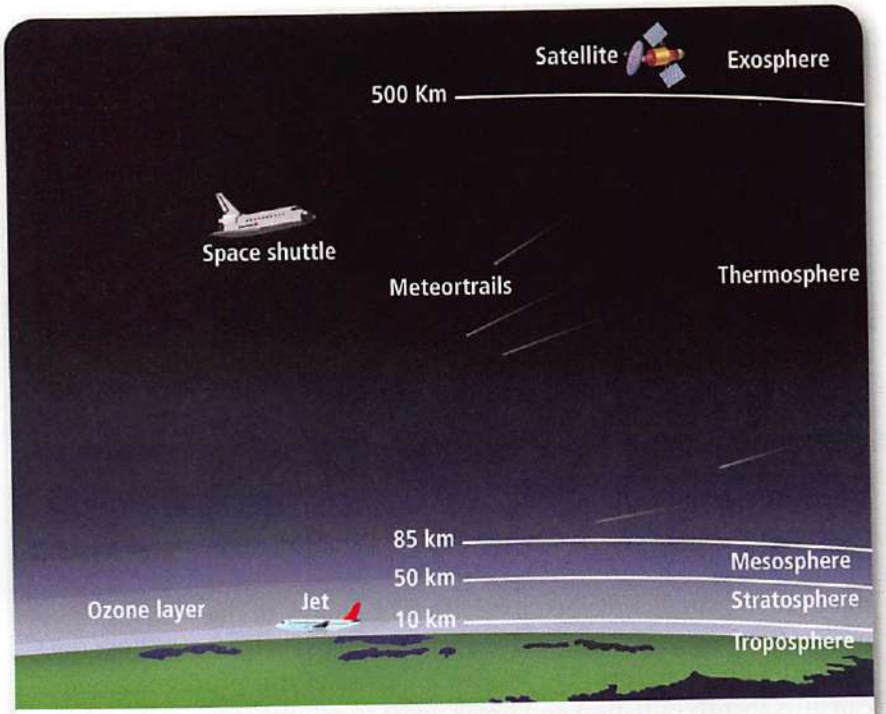


Figure 2 Earth's atmosphere consists of several layers. The protective ozone layer is located in the stratosphere.

The Ozone Layer

If you have ever had a sunburn, you have experienced the damaging effects of ultraviolet radiation from the Sun. Overexposure to ultraviolet radiation is harmful to both plants and animals. Increased levels of a type of ultraviolet radiation called UVB can cause cataracts and skin cancer in humans, lower crop yields in agriculture, and disrupted food chains in nature.

Living organisms have evolved in the presence of UVB, and cells have some ability to repair themselves when exposed to low levels of UVB. However, some scientists believe that when UVB levels reach a certain point, the cells of living organisms will no longer be able to cope, and many organisms will die.

Earth's atmosphere Living organisms on Earth exist because they are protected from high levels of UVB by ozone. Ozone, which is made up of oxygen, is a substance in the atmosphere that absorbs most harmful radiation before it reaches Earth's surface. A **substance,** which is also known as a chemical, is matter that has a definite and uniform composition.

About 90% of Earth's ozone is spread out in a layer that surrounds and protects our planet. As you can see in **Figure 2,** Earth's atmosphere consists of several layers. The lowest layer is called the troposphere and contains the air we breathe. The troposphere is where clouds occur and where airplanes fly. All of Earth's weather occurs in the troposphere. The stratosphere is the layer above the troposphere. It extends from about 10 to 50 kilometers (km) above Earth's surface. The ozone layer that protects Earth is located in the stratosphere.

READING CHECK **Explain** the benefits of ozone in the atmosphere.

RealWorld CHEMISTRY

The Ozone Layer

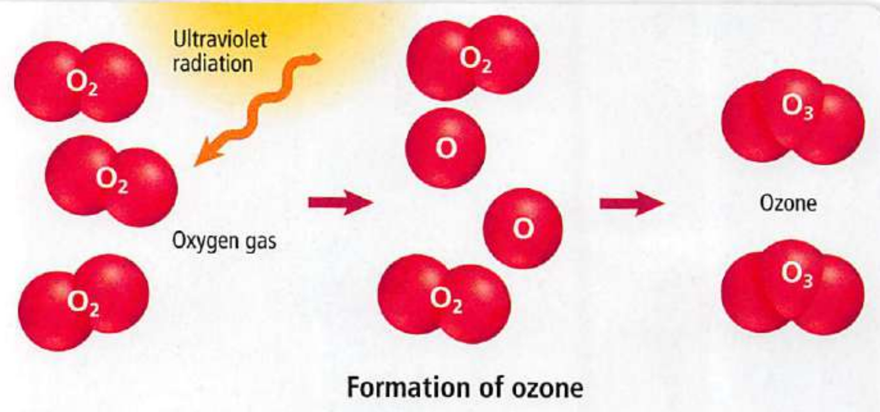
SUNSCREEN To offer some protection from harmful UV radiation, sunscreen can be applied to the skin. Sunscreen helps prevent sunburn and skin cancer. Health professionals recommend the use of sunscreen anytime that you are outdoors and exposed to the Sun's ultraviolet radiation.

VOCABULARY

WORD ORIGIN

Ozone
comes from the Greek word *ozōn,* which means *to smell*

Figure 3 Ultraviolet radiation from the Sun causes some oxygen gas (O_2) to break into individual particles of oxygen (O). These individual particles combine with oxygen gas (O_2) to form ozone (O_3).
Explain ***why there is a balance between oxygen gas and ozone levels in the stratosphere.***



Ozone formation How does ozone enter the stratosphere? When oxygen gas (O_2) is exposed to ultraviolet radiation in the upper regions of the stratosphere, ozone (O_3) is formed. Molecules of oxygen gas are made of two smaller oxygen particles. The energy of the radiation breaks the oxygen gas into individual oxygen particles (O), which then interact with O_2 to form O_3. **Figure 3** illustrates this process. Ozone can also absorb radiation and break apart to reform oxygen gas. Thus, there tends to be a balance between oxygen gas and ozone levels in the stratosphere.

Ozone was first identified and measured in the late 1800s, so its presence has been studied for a long time. It was of interest to scientists because air currents in the stratosphere move ozone around Earth. Ozone forms over the equator, where the rays of sunlight are the strongest, and then flows toward the poles. Thus, ozone makes a convenient marker to follow the flow of air in the stratosphere.

In the 1920s, British scientist G.M.B. Dobson (1889–1976) began measuring the amount of ozone in the atmosphere. Although ozone is formed in the higher regions of the stratosphere, most of it is stored in the lower stratosphere. Ozone can be measured in the lower stratosphere by instruments on the ground or in balloons, satellites, and rockets. Dobson's measurements helped scientists determine the normal amount of ozone that should be in the stratosphere. Three hundred Dobson units (DU) is considered the normal amount of ozone in the stratosphere. Instruments, like those shown in **Figure 4,** monitor the amount of ozone present in the stratosphere today.

Figure 4 Scientists use a variety of equipment, including this Brewer spectrometer, to take ozone measurements.

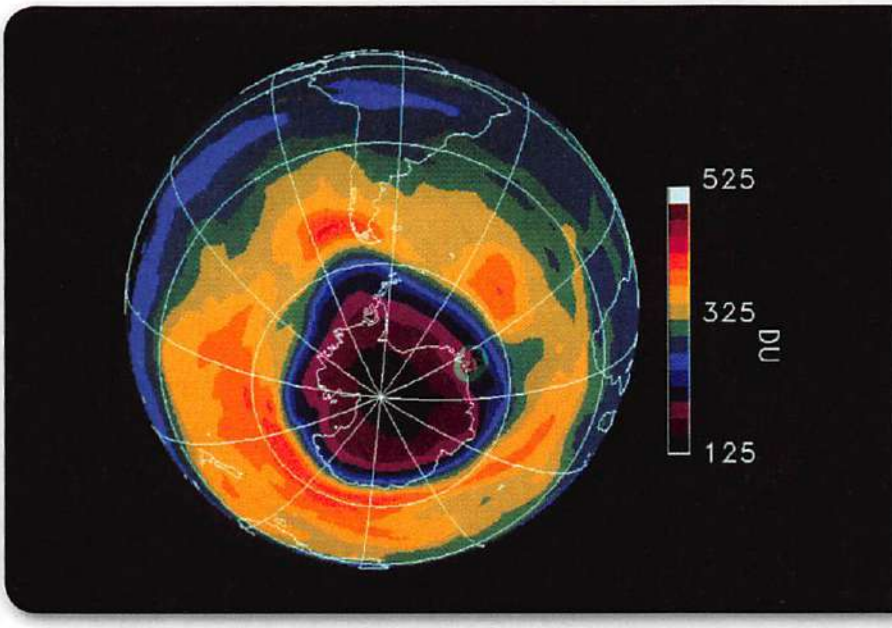


Figure 5 Satellite photos confirmed the British Antarctic Survey team's measurements that the ozone layer was thinning over Antarctica. On this satellite map, the area over Antarctica appears pink, purple, and black. The color-key on the right indicates that the ozone level ranges from 125 to about 200 Dobson Units, which is well below the normal level of 300 Dobson units.

Between 1981 and 1983, a research group from the British Antarctic Survey was monitoring the atmosphere above Antarctica. They measured surprisingly low levels of ozone—readings as low as 160 DU—especially during the Antarctic spring in October. They checked their instruments and repeated their measurements. In October 1985, they reported a confirmed decrease in the amount of ozone in the stratosphere and concluded that the ozone layer was thinning. **Figure 5** shows how the thinning ozone layer looked in October 1990.

Although the thinning of the ozone layer is often called the ozone hole, it is not a hole. The ozone is still present in the atmosphere. However, the protective layer is much thinner than normal. This fact has alarmed scientists, who never expected to find such low levels. Measurements made from balloons, high-altitude planes, and satellites have supported the measurements made from the ground. What could be causing the ozone hole?

Chlorofluorocarbons

The story of the second substance in this chapter begins in the 1920s. Large-scale production of refrigerators, which at first used toxic gases such as ammonia as coolants, was just beginning. Because ammonia fumes could escape from the refrigerator and harm the members of a household, chemists began to search for safer coolants. Thomas Midgley, Jr. synthesized the first chlorofluorocarbons in 1928. A chlorofluorocarbon (CFC) is a substance that consists of chlorine, fluorine, and carbon. Several different substances are classified as CFCs. They are all made in the laboratory and do not occur naturally. CFCs are nontoxic and stable—they do not readily react with other substances. At the time, they seemed to be ideal coolants for refrigerators. By 1935, the first self-contained home air-conditioning units and eight million new refrigerators in the United States used CFCs as coolants. In addition to their use as refrigerants, CFCs were also used in plastic foams, solvents, and as propellants in spray cans.

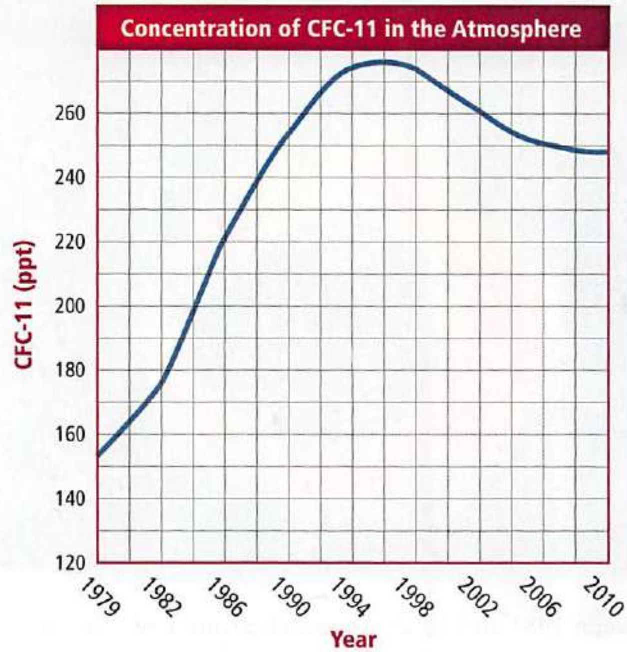
READING CHECK **Explain** why scientists thought CFCs were safe for the environment.

CAREERS IN CHEMISTRY

Environmental Chemist An environmental chemist uses tools from chemistry and other sciences to study how chemicals interact with the physical and biological environment. This includes identifying the sources of pollutants such as ozone and their effects on living organisms.

WebQuest

Figure 6 Scientists collected data on the global use of CFCs and the accumulation of CFCs over Antarctica. CFC-11 is one particular type of CFC. In the graph, the concentration of CFC-11 in the atmosphere is shown in parts per trillion (ppt).



GRAPH CHECK

Describe the trend in the data from 1979 through 2010.

Scientists first began to detect the presence of CFCs in the atmosphere in the 1970s. They decided to measure the amount of CFCs in the stratosphere and found that quantities in the stratosphere increased year after year. By 1990, the concentration of CFCs had reached an all-time high, as shown in **Figure 6.** However, it was widely thought that CFCs did not pose a threat to the environment because they are so stable, and consequently many scientists were not alarmed.

Scientists had noticed and measured two separate phenomena: the protective ozone layer in the atmosphere was thinning, and increasingly large quantities of CFCs were drifting into the atmosphere. Could there be a connection between the two occurrences? Before you learn the answer to this question, you need to understand some of the basic ideas of chemistry and know how chemists—and most scientists—solve scientific problems.

SECTION 1 REVIEW

Section Self-Check

Section Summary

- Chemistry is the study of matter.
- Chemicals are also known as substances.
- Ozone is a substance that forms a protective layer in Earth's atmosphere.
- CFCs are synthetic substances made of chlorine, fluorine, and carbon that were originally thought to be the ideal coolants for refrigeration.

1. MAINIDEA **Explain** why the study of chemistry should be important to everyone.
2. **Define** *substance* and give two examples of things that are substances.
3. **Describe** how the ozone layer forms and why it is important.
4. **Explain** why chlorofluorocarbons were developed and how they were used.
5. **Explain** If cells have the ability to repair themselves after exposure to UVB, why do the increasing levels of UVB in the atmosphere concern scientists?
6. **Explain** why the concentration of CFCs increased in the atmosphere.
7. **Evaluate** why it was important for Dobson's data to be confirmed by satellite photos.

SECTION 2

Chemistry and Matter

MAINIDEA **Branches of chemistry involve the study of different kinds of matter.**

Essential Questions

- How do mass and weight compare and contrast?
- Why are chemists interested in a submicroscopic description of matter?
- What defines the various branches of chemistry?

Review Vocabulary

technology: a practical application of scientific information

New Vocabulary

mass
weight
model

CHEM 4 YOU **Chemistry is sometimes called the central science. Research and technology, such as greener energy and cures for disease, rely on chemistry. Even when you brush your teeth or digest your breakfast, important chemical processes are at work.**

Matter and its Characteristics

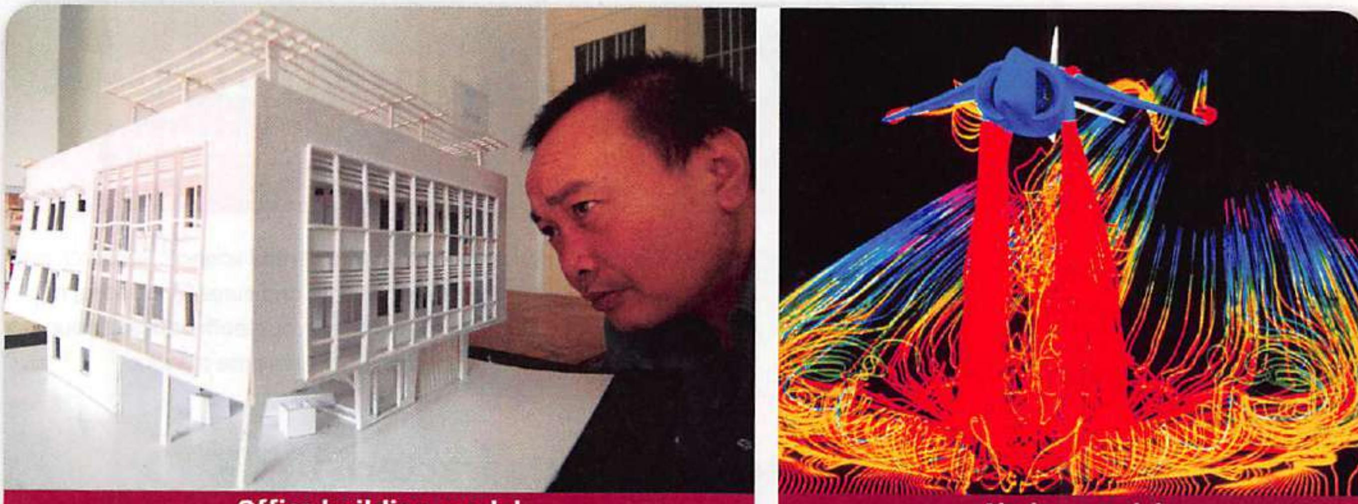
Matter, the stuff of the universe, has many different forms. Everything around you, like the things in **Figure 7,** is matter. Some matter occurs naturally, such as ozone, and other substances are not natural, such as CFCs, which you read about in Section 1.

You might realize that everyday objects are composed of matter, but how do you define matter? Recall that matter is anything that has mass and takes up space. Also recall that **mass** is a measurement that reflects the amount of matter. You know that your textbook has mass and takes up space, but is air matter? You cannot see it and you cannot always feel it. However, when you inflate a balloon, it expands to make room for the air. The balloon gets heavier. Thus, air must be matter. Is everything matter? The thoughts and ideas that fill your head are not matter; neither are heat, light, radio waves, nor magnetic fields. What else can you name that is not matter?

Mass and weight Have you ever used a bathroom scale to measure your weight? **Weight** is a measure not only of the amount of matter but also of the effect of Earth's gravitational pull on that matter. This force is not exactly the same everywhere on Earth and actually becomes less as you move away from Earth's surface at sea level. You might not notice a difference in your weight from one place to another, but subtle differences do exist.

Figure 7 Everything in this photo is matter and has mass and weight.
Compare and contrast *mass and weight.*

David Young-Wolff/PhotoEdit



Office building model

Airplane model

■ **Figure 8** Scientists use models to visualize complex ideas, such as the materials and structure used to build office buildings. They also use models to test a concept, such as a new airplane design, before it is mass produced.

Infer ***why chemists use models to study atoms.***

It might seem more convenient for scientists to simply use weight instead of mass. Why is it so important to think of matter in terms of mass? Scientists need to be able to compare the measurements that they make in different parts of the world. They could identify the gravitational force every time they weigh something, but that would not be practical or convenient. They use mass as a way to measure matter independently of gravitational force.

Structure and observable characteristics What can you observe about the outside of your school building? You know that there is more to the building than what you can observe from the outside. Among other things, there are beams inside the walls that give the building structure, stability, and function. Consider another example. When you bend your arm at the elbow, you observe that your arm moves, but what you cannot see is that muscles under the skin contract and relax to move your arm.

FOLDABLES®

Incorporate information from this section into your Foldable.

Much of matter and its behavior is macroscopic; that is, you do not need a microscope to observe it. You will learn in Chapter 3 that the tremendous variety of stuff around you can be broken down into more than a hundred types of matter called elements, and that elements are made up of particles called atoms. Atoms are so tiny that they cannot be seen even with optical microscopes. Thus, atoms are submicroscopic. They are so small that over a trillion atoms could fit onto the period at the end of this sentence. The structure, composition, and behavior of all matter can be explained on a submicroscopic level—or the atomic level. All that we observe about matter depends on atoms and the changes they undergo.

Chemistry seeks to explain the submicroscopic events that lead to macroscopic observations. One way this can be done is by making a model. A **model** is a visual, verbal, or mathematical explanation of experimental data. Scientists use many types of models to represent things that are hard to visualize, such as the structure and materials used in the construction of a building and the computer model of the airplane shown in **Figure 8.** Chemists also use several different types of models to represent matter, as you will soon learn.

VOCABULARY

SCIENCE USAGE V. COMMON USAGE

Weight

Science usage: the measure of the amount of matter in and the gravitational force exerted on an object

The weight of an object is the product of its mass and the local acceleration of gravity.

Common usage: the relative heaviness of an object

The puppy grew so quickly it doubled its weight in a matter of weeks.

☑ READING CHECK **Identify** two additional types of models that are used by scientists.

Explore the **branches of chemistry** with an interactive table. Concepts In Motion

Table 1 Some Branches of Chemistry

Branch	Area of Emphasis	Examples of Emphasis
Organic chemistry	most carbon-containing chemicals	pharmaceuticals, plastics
Inorganic chemistry	in general, matter that does not contain carbon	minerals, metals and nonmetals, semiconductors
Physical chemistry	the behavior and changes of matter and the related energy changes	reaction rates, reaction mechanisms
Analytical chemistry	components and composition of substances	food nutrients, quality control
Biochemistry	matter and processes of living organisms	metabolism, fermentation
Environmental chemistry	matter and the environment	pollution, biochemical cycles
Industrial chemistry	chemical processes in industry	paints, coatings
Polymer chemistry	polymers and plastics	textiles, coatings, plastics
Theoretical chemistry	chemical interactions	many areas of emphasis
Thermochemistry	heat involved in chemical processes	heat of reaction

Chemistry: The Central Science

Recall from Section 1 that chemistry is the study of matter and the changes that it undergoes. A basic understanding of chemistry is central to all sciences—biology, physics, Earth science, ecology, and others. Because there are so many types of matter, there are many areas of study in the field of chemistry. Chemistry is traditionally broken down into branches that focus on specific areas, such as those listed in **Table 1.** Although chemistry is divided into specific areas of study, many of the areas overlap. For example, as you can see from **Table 1,** an organic chemist might study plastics, but an industrial chemist or a polymer chemist could also focus on plastics.

Get help with **mass and weight relationships.**

Personal Tutor

SECTION 2 REVIEW

Section Self-Check

Section Summary

- Models are tools that scientists, including chemists, use.
- Macroscopic observations of matter reflect the actions of atoms on a submicroscopic scale.
- There are several branches of chemistry, including organic chemistry, inorganic chemistry, physical chemistry, analytical chemistry, and biochemistry

8. MAINIDEA **Explain** why there are different branches of chemistry.
9. **Explain** why scientists use mass instead of weight for their measurements.
10. **Summarize** why it is important for chemists to study changes in the world at a submicroscopic level.
11. **Infer** why chemists use models to study submicroscopic matter.
12. **Identify** three models that scientists use, and explain why each model is useful.
13. **Evaluate** How would your mass and weight differ on the Moon? The gravitational force of the Moon is one-sixth the gravitational force on Earth.
14. **Evaluate** If you put a scale in an elevator and weigh yourself as you ascend and then descend, does the scale have the same reading in both instances? Explain your answer.

SECTION 3

Scientific Methods

MAINIDEA **Scientists use scientific methods to systematically pose and test solutions to questions and assess the results of the tests.**

Essential Questions

- What are the common steps of scientific methods?
- What are the similarities and differences between qualitative data and quantitative data?
- In an experiment, which variable is the independent variable, which is the dependent variable, and which are controls?
- What is the difference between a theory and a scientific law?

Review Vocabulary

systematic approach: an organized method of solving a problem

New Vocabulary

scientific method
qualitative data
quantitative data
hypothesis
experiment
independent variable
dependent variable
control
conclusion
theory
scientific law

CHEM 4 YOU **When packing for a long trip, how do you start? Do you throw all of your clothes into a suitcase, or do you plan what you are going to wear? Usually, it is most effective to make a plan. Similarly, scientists develop and follow a plan that helps them investigate the world.**

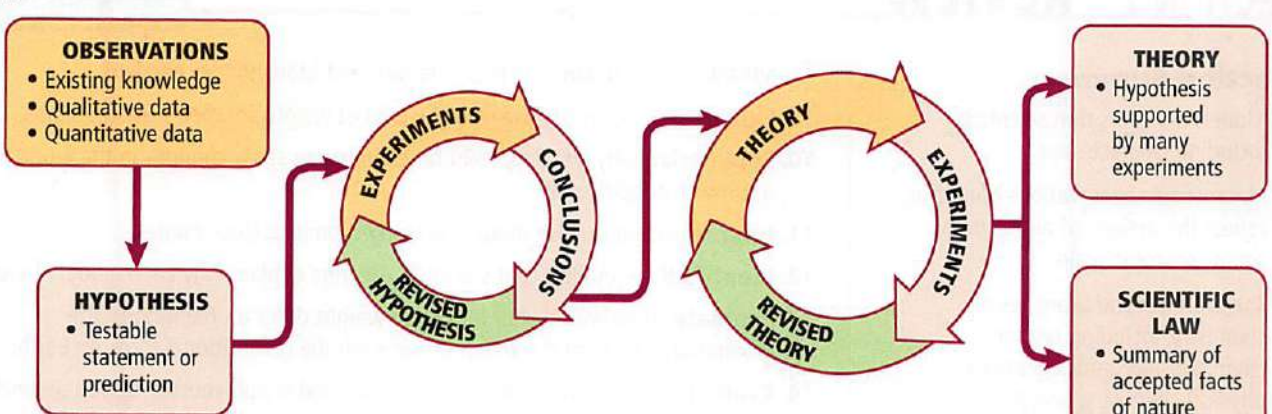
A Systematic Approach

You might have worked with a group on an experiment in the laboratory in a previous science course. If so, you know that each person in the group probably has a different idea about how to do the lab. Having many different ideas about how to do the lab is one of the benefits of many people working together. However, communicating ideas effectively to one another and combining individual contributions to form a solution can be difficult in group work.

Scientists approach their work in a similar way. Each scientist tries to understand his or her world based on a personal point of view and individual creativity. Often, the work of many scientists is combined in order to gain new insight. It is helpful if all scientists use common procedures as they conduct their experiments.

A **scientific method** is a systematic approach used in scientific study, whether it is chemistry, biology, physics, or another science. It is an organized process used by scientists to do research, and it provides a method for scientists to verify the work of others. An overview of the typical steps of a scientific method is shown in **Figure 9.** The steps are not meant to be used as a checklist, or to be done in the same order each time. Therefore, scientists must describe their methods when they report their results. If other scientists cannot confirm the results after repeating the method, then doubt arises over the validity of the results.

Figure 9 The steps in a scientific method are repeated until a hypothesis is supported or discarded.



MiniLAB

iLab Station

Develop Observation Skills

Why are observation skills important in chemistry? Observations are often used to make inferences. An inference is an explanation or interpretation of observations.

Procedure

1. Read and complete the lab safety form.
2. Add **water** to a **petri dish** to a height of 0.5 cm. Use a **graduated cylinder** to measure 1 mL of **vegetable oil,** then add it to the petri dish.
3. Dip the end of a **toothpick** into **liquid dishwashing detergent.**
4. Touch the tip of the toothpick to the water at the center of the petri dish. Record your detailed observations.
5. Add **whole milk** to a **second petri dish** to a height of 0.5 cm.
6. Place one drop each of **four different food colorings** in four different locations on the surface of the milk. Do not put a drop of food coloring in the center.
7. Repeat Steps 3 and 4.

Analysis

1. **Describe** what you observed in Step 4.
2. **Describe** what you observed in Step 7.
3. **Infer** Oil, the fat in milk, and grease belong to a class of substances called lipids. What can you infer about the addition of detergent to dishwater?
4. **Explain** why observations skills were important in this chemistry lab.

Observation You make observations throughout your day in order to make decisions. Scientific study usually begins with simple observation. An observation is the act of gathering information. Often, the types of observations scientists make first are **qualitative data**—information that describes color, odor, shape, or some other physical characteristic. In general, anything that relates to the five senses is qualitative: how something looks, feels, sounds, tastes, or smells.

Chemists frequently gather another type of data. For example, they can measure temperature, pressure, volume, the quantity of a chemical formed, or how much of a chemical is used up in a reaction. This numerical information is called **quantitative data.** It tells how much, how little, how big, how tall, or how fast. What kind of qualitative and quantitative data can you gather from **Figure 10?**

Hypothesis Recall the stories of the two substances that you read about in Section 1. Even before quantitative data showed that ozone levels were decreasing in the stratosphere, scientists observed CFCs there. Chemists Mario Molina and F. Sherwood Rowland were curious about how long CFCs could exist in the atmosphere.

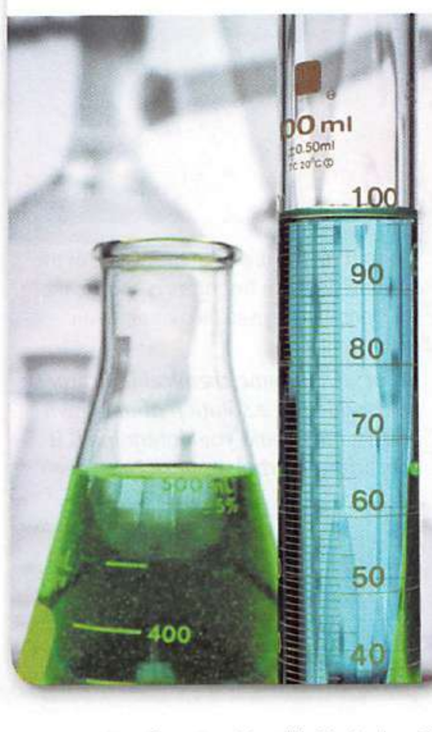
Molina and Rowland examined the interactions that can occur among various chemicals in the troposphere. They determined that CFCs were stable there for long periods of time, but they also knew that CFCs drift upward into the stratosphere. They formed a hypothesis that CFCs break down in the stratosphere due to interactions with ultraviolet light from the Sun. In addition, the calculations they made led them to hypothesize that chlorine produced by this interaction would break down ozone.

A **hypothesis** is a tentative, testable statement or prediction about what has been observed. Molina and Rowland's hypothesis stated what they believed to be happening, even though there was no formal evidence at that point to support the statement.

READING CHECK **Infer** why a hypothesis is tentative.

Figure 10 Quantitative data are numerical information. Qualitative data are observations made by using the human senses.

Identify *the quantitative and qualitative data in the photo.*



Art Vandalay/Photodisc/Getty Images

■ **Figure 11** These materials can be used to determine the effect of temperature on the rate at which table salt dissolves.

Experiments A hypothesis is meaningless unless there are data to support it. Thus, forming a hypothesis helps the scientist focus on the next step in a scientific method—the experiment. An **experiment** is a set of controlled observations that test the hypothesis. The scientist must carefully plan and set up one or more laboratory experiments in order to change and test one variable at a time. A variable is a quantity or condition that can have more than one value.

Suppose your chemistry teacher asks your class to use the materials shown in **Figure 11** to design an experiment to test the hypothesis that table salt dissolves faster in hot water than in water at room temperature (20°C). Because temperature is the variable that you plan to change, it is the **independent variable.** Your group determines that a given quantity of salt completely dissolves within 1 min at 40°C, but that the same quantity of salt dissolves after 3 min at 20°C. Thus, temperature affects the rate at which the salt dissolves. This rate is called the **dependent variable** because its value changes in response to a change in the independent variable. Although your group can determine the way in which the independent variable changes, it has no control over the way the dependent variable changes.

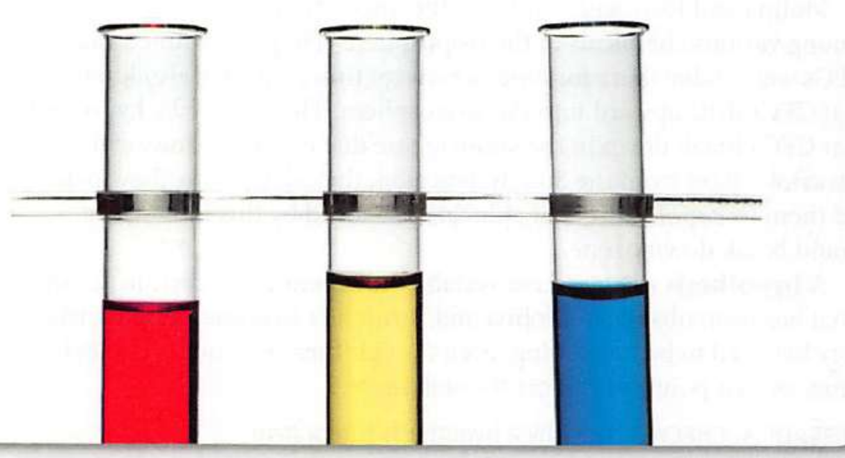
☑ READING CHECK **Explain** the difference between a dependent and an independent variable.

Other factors What other factors could you vary in your experiment? Would the amount of salt you try to dissolve make a difference? The amount of water you use? Would stirring the mixture affect your results? The answer to all of these questions might be yes. You must plan your experiment so that these variables are the same at each temperature, or you will not be able to tell clearly what caused your results. In a well-planned experiment, the independent variable should be the only condition that affects the experiment's outcome. A constant is a factor that is not allowed to change during the experiment. The amount of salt, water, and stirring must be constant at each temperature.

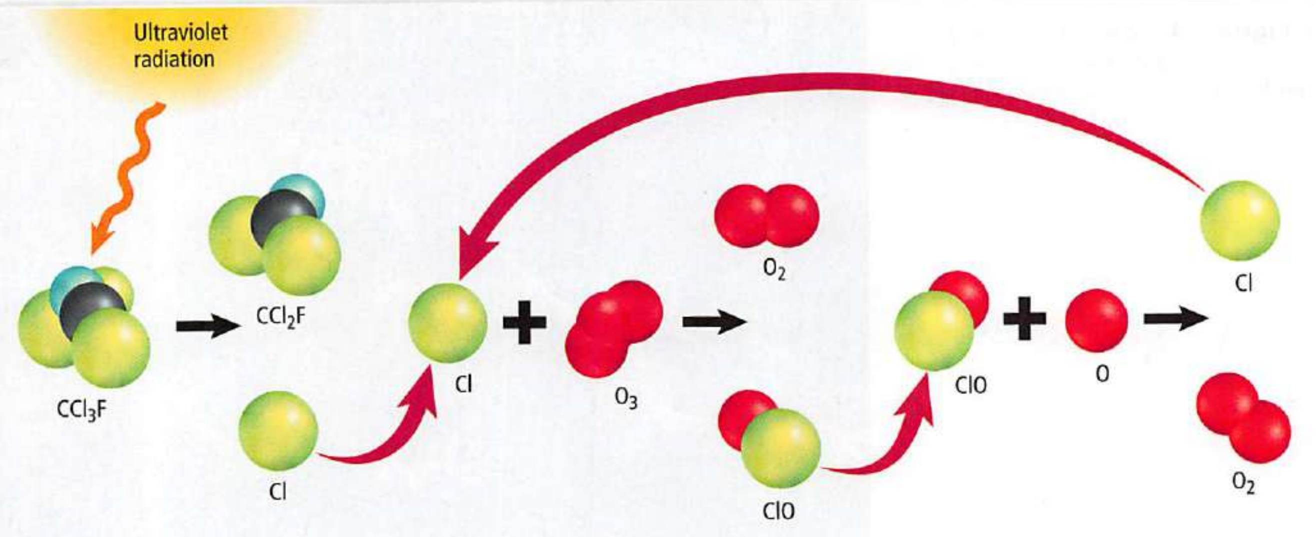
In many experiments, it is valuable to have a **control,** that is, a standard for comparison. In the above experiment, the room-temperature water is the control. **Figure 12** shows a different type of control. A chemical indicator has been added to each of three test tubes. An acidic solution is in the test tube on the left, and the indicator turns red. The test tube in the middle contains water, and the indicator is yellow. The test tube on the right contains a basic solution, and the indicator turns blue.

■ **Figure 12** Because the acidity of the solutions in these test tubes is known, these solutions can be used as controls in an experiment.

Infer ***If the same chemical indicator were added to a solution of unknown acidity, how could you determine if it was acidic, neutral, or basic?***



(t)Matt Meadows, (b)Martyn F. Chillmaid/Science Photo Library/Photo Researchers



Molina and Rowland's model predicted that ultraviolet radiation causes chlorine (Cl) to split off from a CFC (CCl_3F).

The chlorine then destroys the ozone by combining with it to form oxygen gas (O_2) and chlorine monoxide (ClO).

A free oxygen (O) combines with the chlorine monoxide (ClO) to form oxygen gas (O_2) and a chlorine (Cl). Then, the chlorine is free to combine with another ozone. The process begins again.

Figure 13 Molina and Rowland's model showed how CFCs could destroy ozone.

Controlling variables The interactions described between CFCs and ozone in Molina and Rowland's hypothesis take place high overhead. Many variables are involved. For example, there are several gases present in the stratosphere. Thus, it would be difficult to determine which gases, or if all gases, are causing decreasing ozone levels. Winds, variations in ultraviolet light, and other factors could change the outcome of any experiment on any given day, making comparisons difficult. Sometimes, it is easier to simulate conditions in a laboratory, where the variables can be more easily controlled.

Conclusion An experiment might generate a large amount of data. Scientists take the data, analyze it, and check it against the hypothesis to form a conclusion. A **conclusion** is a judgment based on the information obtained. A hypothesis can never be proven. Therefore, when the data support a hypothesis, this only indicates that the hypothesis might be true. If further evidence does not support it, then the hypothesis must be discarded or modified. The majority of hypotheses are not supported, but the data might still yield new and useful information.

Molina and Rowland formed a hypothesis about the stability of CFCs in the stratosphere. The data that they gathered supported their hypothesis. They developed a model in which the chlorine formed by the breakdown of CFCs would react over and over again with ozone.

A model can be tested and used to make predictions. Molina and Rowland's model predicted the formation of chlorine and the depletion of ozone, as shown in **Figure 13.** Another research group found evidence of interactions between ozone and chlorine when taking measurements in the stratosphere, but they did not know the source of the chlorine. Molina and Rowland's model predicted a source of the chlorine. They came to the conclusion that ozone in the stratosphere could be destroyed by CFCs, and they had enough support for their hypothesis to publish their discovery. They won the Nobel Prize in 1995.

View an **animation about ozone depletion.**

Concepts In Motion

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■ **Figure 14** It does not matter how many times skydivers leap from a plane; Newton's law of universal gravitation applies every time.

moodboard/the Agency Collection/Getty Images

Theory and Scientific Law

A **theory** is an explanation of a natural phenomenon based on many observations and investigations over time. You might have heard of Einstein's theory of relativity or the atomic theory. A theory states a broad principle of nature that has been supported over time. All theories are still subject to new experimental data and can be modified. Also, theories often lead to new conclusions. A theory is considered valid if it can be used to make predictions that are proven true.

Sometimes, many scientists come to the same conclusion about certain relationships in nature and they find no exceptions to these relationships. For example, you know that no matter how many times skydivers, like those shown in **Figure 14,** leap from a plane, they always return to Earth's surface. Sir Isaac Newton was so certain that an attractive force exists between all objects that he proposed his law of universal gravitation. Newton's law is a **scientific law**—a relationship in nature that is supported by many experiments. It is up to scientists to develop further hypotheses and experiments to explain why these relationships exist.

SECTION 3 REVIEW

Section Self-Check

Section Summary

- Scientific methods are systematic approaches to problem solving.
- Qualitative data describe an observation; quantitative data use numbers.
- Independent variables are changed in an experiment. Dependent variables change in response to the independent variable.
- A theory is a hypothesis that is supported by many experiments.

15. MAINIDEA **Explain** why scientists do not use a standard set of steps for every investigation they conduct.

16. Differentiate Give an example of quantitative and qualitative data.

17. Evaluate You are asked to study the effect of temperature on the volume of a balloon. The balloon's size increases as it is warmed. What is the independent variable? The dependent variable? What factor is held constant? How would you construct a control?

18. Distinguish Jacques Charles described the direct relationship between temperature and volume of all gases at constant pressure. Should this be called Charles's law or Charles's theory? Explain.

19. Explain Good scientific models can be tested and used to make predictions. What did Molina and Rowland's model of the interactions of CFCs and ozone in the atmosphere predict would happen to the amount of ozone in the stratosphere as the level of CFCs increased?

SECTION 4

Scientific Research

MAINIDEA **Some scientific investigations result in the development of technology that can improve our lives and the world around us.**

Essential Questions

- How do pure research, applied research, and technology compare and contrast?
- What are some of the important rules for laboratory safety?

Review Vocabulary

synthetic: something that is human-made and does not necessarily occur in nature

New Vocabulary

pure research
applied research

CHEM 4 YOU **Much of the information that scientists obtain through basic research is used to meet a specific need. For example, X-rays were discovered by scientists conducting basic research on electrical discharge through gases. Later, it was discovered that X-rays could be used to diagnose medical problems.**

Types of Scientific Investigations

Every day in the media—through TV, newspapers, magazines, or the Internet—the public is bombarded with the results of scientific investigations. Many deal with the environment, medicine, or health. As a consumer, you are asked to evaluate the results of scientific research and development. How do scientists use qualitative and quantitative data to solve different types of scientific problems?

Scientists conduct **pure research** to gain knowledge for the sake of knowledge itself. Molina and Rowland were motivated by curiosity and, thus, conducted research on CFCs and their interactions with ozone as pure research. No environmental evidence at the time indicated that there was a correlation to their model in the stratosphere. Their research showed only that CFCs could speed the breakdown of ozone in a laboratory setting.

By the time the ozone hole was reported in 1985, scientists had made measurements of CFC levels in the stratosphere that supported the hypothesis that CFCs could be responsible for the depletion of ozone. The early pure research done only for the sake of knowledge became applied research. **Applied research** is research undertaken to solve a specific problem. Scientists continue to monitor the amount of CFCs in the atmosphere and the annual changes in the amount of ozone in the stratosphere, as shown in **Figure 15.** Applied research is also being conducted to find replacement chemicals for the CFCs that are now banned.

Figure 15 This UV-visible spectrometer (UV-Vis) is used to measure ozone and other stratospheric gases during the dark winter months in Antarctica.

Hank Morgan/Photo Researchers

■ **Figure 16** After its discovery, nylon was used mainly for war materials and was not available for home use until after World War II. Today it is used in a variety of products.

Strands of nylon can be pulled from the top layer of solution.

Nylon fibers are used to make hook-and-loop fastener tape.

Chance discoveries Often, a scientist conducts experiments and reaches a conclusion that is far different from what was predicted. Some truly wonderful discoveries in science have been made unexpectedly. You might be familiar with the two examples described below.

Connection to Biology Alexander Fleming is famous for making several accidental discoveries. In one accidential discovery, Fleming found that one of his plates of *Staphylococcus* bacteria had been contaminated by a greenish mold, later identified as *Penicillium.* He observed it carefully and saw a clear area around the mold where the bacteria had died. In this case, a chemical in the mold—penicillin—was responsible for killing the bacteria.

The discovery of nylon is another example of an accidental discovery. In 1930, Julian Hill, an employee of E.I. DuPont de Nemours and Company, dipped a hot glass rod in a mixture of solutions and unexpectedly pulled out long fibers similar to those shown in **Figure 16.** Hill and his colleagues pursued the development of these fibers as a synthetic silk that could withstand high temperatures. They eventually developed nylon in 1934. During World War II, nylon was used as a replacement for silk in parachutes. Today, nylon is used extensively in textiles and some kinds of plastics. It is also used to make hook-and-loop tape, as shown in **Figure 16.**

Students in the Laboratory

Watch a video about **criminal science investigation.**

Video

In your study of chemistry, you will learn many facts about matter. You will also do investigations and experiments in which you will be able to form hypotheses, test hypotheses, gather data, analyze data, and draw conclusions.

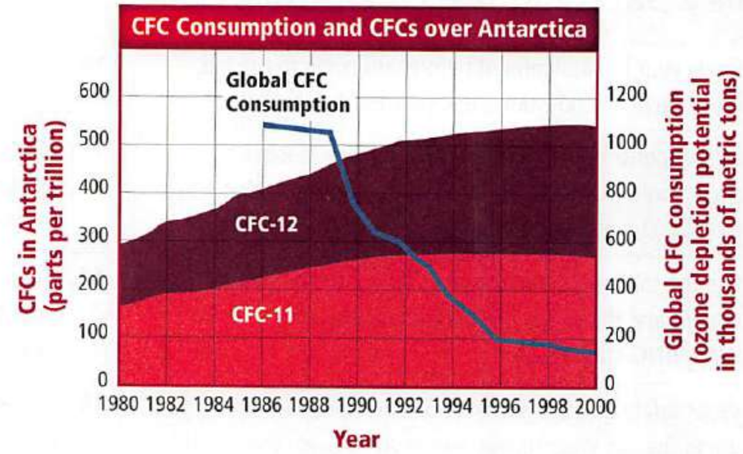
When you work in the chemistry laboratory, you are responsible for your safety and the safety of people working nearby. Often, many people are working in a small space during a lab, so it is important that everyone practice safe laboratory procedures. **Table 2** lists some safety rules that you should follow each time you enter the lab. Chemists and all other scientists use these safety rules as well.

Table 2 Safety in the Laboratory

1. Study your lab assignment before you come to the lab. If you have any questions, ask your teacher for help.	**16.** Keep combustible materials away from open flames.
2. Do not perform experiments without your teacher's permission. Never work alone in the laboratory. Know how to contact help, if necessary.	**17.** Handle toxic and combustible gases only under the direction of your teacher. Use the fume hood when such materials are present.
3. Use the table on the inside front cover of this textbook to understand the safety symbols. Read and adhere to all **WARNING** statements.	**18.** When heating a substance in a test tube, be careful not to point the mouth of the test tube at another person or yourself. Never look down into the mouth of a test tube.
4. Wear safety goggles and a laboratory apron whenever you are in the lab. Wear gloves whenever you use chemicals that cause irritations or can be absorbed through the skin. If you have long hair, you must tie it back.	**19.** Do not heat graduated cylinders, burettes, or pipettes with a laboratory burner.
5. Do not wear contact lenses in the lab, even under goggles. Lenses can absorb vapors and are difficult to remove during an emergency.	**20.** Use caution and proper equipment when handling a hot apparatus or glassware. Hot glass looks the same as cool glass.
6. Avoid wearing loose, draping clothing and dangling jewelry. Wear only closed-toe shoes in the lab.	**21.** Dispose of broken glass, unused chemicals, and products of reactions only as directed by your teacher.
7. Keep food, beverages, and chewing gum out of the lab. Never eat in the lab.	**22.** Know the correct procedure for preparing acid solutions. Always add the acid to the water slowly.
8. Know where to find and how to use the fire extinguisher, safety shower, fire blanket, first-aid kit, and gas and electrical power shutoffs.	**23.** Keep the balance area clean. Never place chemicals directly on the pan of a balance.
9. Immediately clean up spills on the floor and keep all walkways clear of objects, such as backpacks, to prevent accidental falls or tripping. Report any accident, injury, incorrect procedure, or damaged equipment to your teacher.	**24.** After completing an experiment, clean and put away your equipment. Clean your work area. Make sure the gas and water are turned off. Wash your hands with soap and water before you leave the lab.
10. If chemicals come in contact with your eyes or skin, flush the area immediately with large quantities of water. Immediately inform your teacher of the nature of the spill.	
11. Handle all chemicals carefully. Check the labels of all bottles before removing the contents. Read the label three times: before you pick up the container, when the container is in your hand, and when you put the bottle back.	
12. Do not take reagent bottles to your work area unless instructed to do so. Use test tubes, paper, or beakers to obtain your chemicals. Take only small amounts. It is easier to get more than to dispose of excess.	
13. Do not return unused chemicals to the stock bottle.	
14. Do not insert droppers into reagent bottles. Pour a small amount of the chemical into a beaker.	
15. Never taste any chemicals. Never draw any chemicals into a pipette with your mouth.	

Matt Meadows

■ **Figure 17** This graph shows the concentration of two common CFCs in the atmosphere over Antarctica and the global consumption of CFCs from 1980 to 2000. While CFC consumption began to decrease drastically a few years after the signing of the Montreal Protocol, the concentration of CFCs above Antarctica continued to increase for awhile before slowly leveling out.



☑ GRAPH CHECK **Identify** when CFCs in Antarctica began to level off after national leaders signed the Montreal Protocol.

The Story Continues

Now, back to the two substances that you have been reading about. A lot has happened since the 1970s, when Molina and Rowland hypothesized that CFCs broke down stratospheric ozone. The National Oceanic and Atmospheric Administration (NOAA) and many other groups are actively collecting historic and current data on CFCs in the atmosphere and ozone concentrations in the stratosphere. Through applied research, scientists determined that not only do CFCs react with ozone, but a few other substances react as well. Carbon tetrachloride and methyl chloroform are two additional substances that harm the ozone. Substances that contain bromine can also damage the ozone.

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The Montreal Protocol Because ozone depletion is an international concern, nations banded together to try to solve this problem. In 1987, leaders from many nations met in Montreal, Canada, and signed the Montreal Protocol. By signing this agreement, nations agreed to phase out the use of these compounds and place restrictions on how they should be used in the future. As you can see from **Figure 17,** the global use of CFCs began to decline after the Montreal Protocol was signed. However, the graph shows that the amount of CFCs measured over Antarctica did not decline immediately.

The ozone hole today Scientists have also learned that the ozone hole forms each year over Antarctica during the spring. Stratospheric ice clouds form over Antarctica when temperatures there drop below −78°C. These clouds produce changes that promote the production of chemically active chlorine and bromine. When temperatures begin to warm in the spring, this chemically active chlorine and bromine react with ozone, causing ozone depletion. This ozone depletion causes the ozone hole to form over Antarctica. Some ozone depletion also occurs over the Arctic, but temperatures do not remain low for as long, which means less ozone depletion in the Arctic. Upon further research, scientists have also determined that ozone thinning has occurred above every continent.

☑ READING CHECK **Explain** what triggers the formation of the ozone hole over Antarctica.

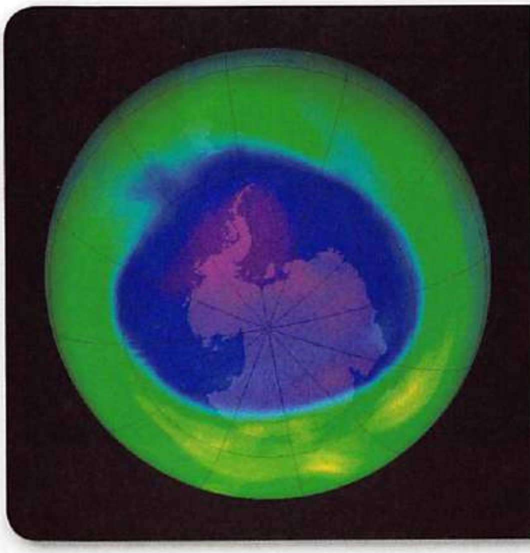


Figure 18 The ozone hole over Antarctica reached its maximum level of thinning in September 2005. The color-key below shows what the colors represent in this colorized satellite image.

Compare ***How do these ozone levels compare with what is considered normal?***

Figure 18 shows the ozone hole over Antarctica in September 2005. The ozone thinning over Antarctica reached its maximum for the year during this month. If you compare the color-coded key to the satellite image, you can see that the ozone level is between 110 and 200 DU. Notice the area surrounding the ozone hole. Much of this area has ozone levels around 300 DU, which is considered normal.

Scientists are not sure when the ozone layer will begin to recover. Originally, scientists predicted that it would begin to recover in 2050. However, new computer models predict that it will not begin to recover until 2068. The exact date of its recovery is not as important as the fact that it will recover given time.

VOCABULARY
WORD ORIGIN
Recover
to bring back to normal
It takes several days to recover from the flu.

Data Analysis LAB

Based on Real Data*

Interpret Graphs

How do ozone levels vary throughout the year above Antarctica? Many agencies monitor the concentration of ozone in the stratosphere over Antarctica.

Data and Observation

This graph displays data from NASA collected over Antarctica. Data values below 220 Dobson Units are defined as the region of the ozone hole area.

Think Critically

1. **Describe** the trend in the data for 1979–2008.
2. **Evaluate** how the 2009 data compare with the data from 1979–2008.
3. **Identify** the month during which the ozone levels were the lowest in 1979–2008. In 2009?
4. **Assess** Do these data points back up what you learned in this chapter about ozone depletion? Explain your answer.

*Data obtained from Ozone Hole Watch. 2010. *National Aeronautics and Space Administration.*

NASA/Science Photo Library/Photo Researchers

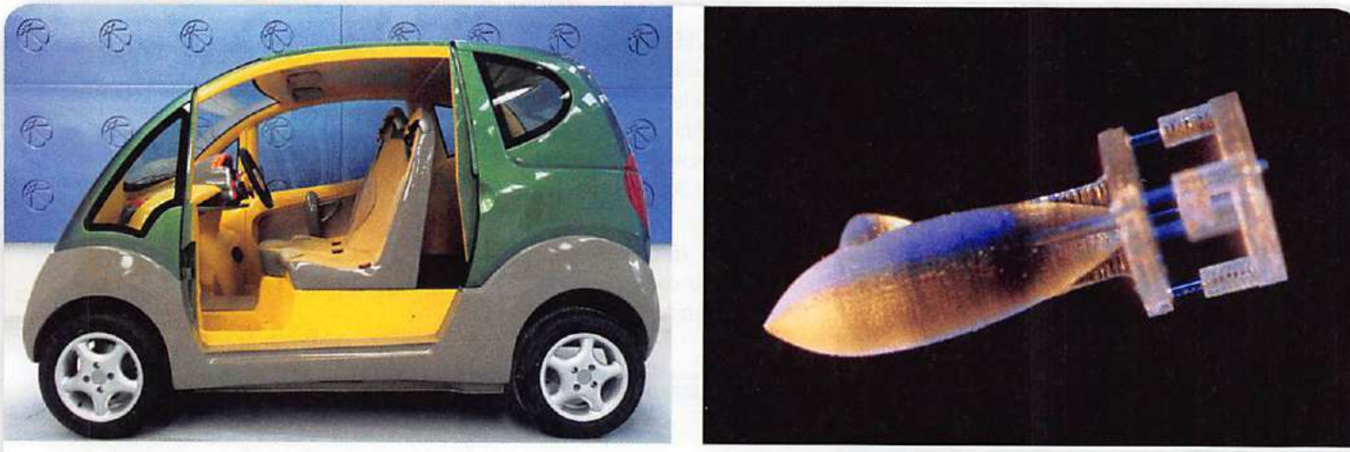


Figure 19 This car, which is powered by compressed air, and this tiny submarine, which is only 4 mm long, are examples of technologies that are made possible by the study of matter.

The Benefits of Chemistry

Chemists are an important part of the team of scientists that solve many of the problems or issues that we face today. Chemists are not only involved in resolving the ozone depletion problem. They are also involved in finding cures or vaccines for diseases, such as AIDS and influenza. Almost every situation that you can imagine involves a chemist, because everything in the universe is made of matter.

Figure 19 shows some of the advances in technology that are possible because of the study of matter. The car on the left is powered by compressed air. When the compressed air is allowed to expand, it pushes the pistons that move the car. Because the car is powered by compressed air, no pollutants are released. The photo on the right shows a tiny submarine that is made by computer-aided lasers. This submarine, which is only 4 mm long, might be used for detecting and repairing defects in the human body.

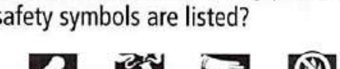
SECTION 4 REVIEW

Section Self-Check

Section Summary

- Scientific methods can be used in pure research or in applied research.
- Some scientific discoveries are accidental, and some are the result of diligent research in response to a need.
- Laboratory safety is the responsibility of everyone in the laboratory.
- Many of the conveniences we enjoy today are technological applications of chemistry.

20. MAINIDEA **Name** three technological products that have improved our lives or the world around us.
21. **Compare and contrast** pure research and applied research.
22. **Classify** Is technology a product of pure research or applied research? Explain.
23. **Summarize** the reason behind each of the following.
    - **a.** Wear goggles and an apron in the lab even if you are only an observer.
    - **b.** Do not return unused chemicals to the stock bottle.
    - **c.** Do not wear contact lenses in the laboratory.
    - **d.** Avoid wearing loose, draping clothing and dangling jewelry.
24. **Interpret Scientific Diagrams** What safety precautions should you take when the following safety symbols are listed?



A Tale of Two Chemicals

Part 1: Ozone

The Ozone Layer

- Absorbs most of ultraviolet radiation (UV) from the sun

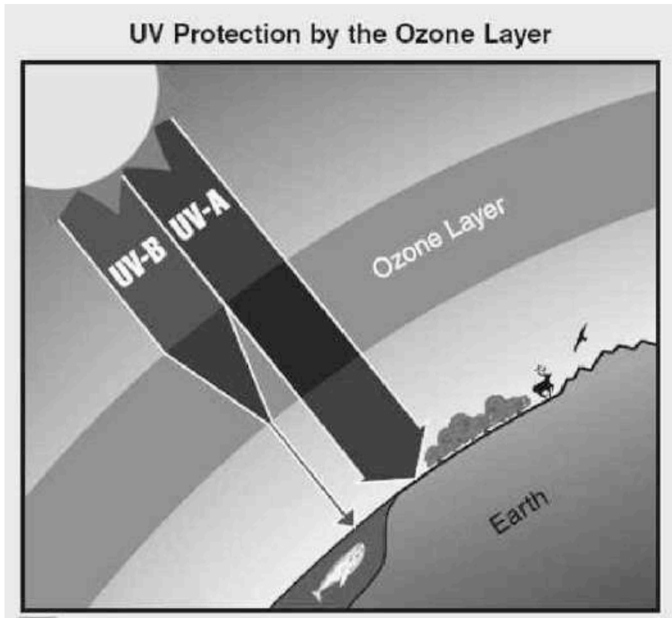
–Protects plants and animals from damage due to UV radiation

– Located in stratosphere

▪

–Commercial aircraft fly in lower stratosphere

– Clouds located in troposphere, so it is turbulent

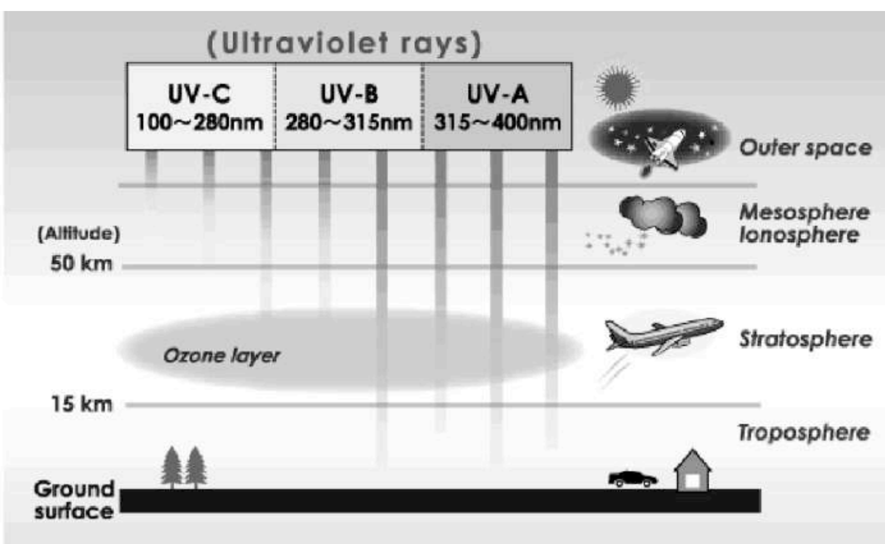


UV Radiation

- There are three types of UV radiation
  - UV-A
    –
    – A: Ages your skin
  - UV-B
    – Medium energy
    – UV-B: Burns your skin
  - UV-C
    – Highest energy
    – Most damaging

UV Radiation

- UV-A
  - Not strongly absorbed by ozone
- UV-B
  - Partially absorbed by ozone
- UV-C
  - Completely absorbed by ozone



UV Radiation

- Ozone reduces UV-B exposure

–In humans, UV-B exposure increases risk of:

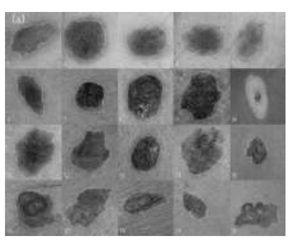
▪Skin cancers

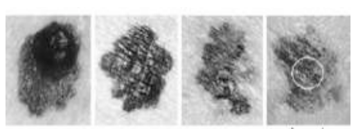
–Melanoma can be lethal if not caught early

▪Cataracts

▪Suppressed immune system

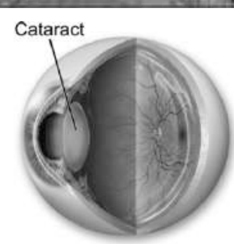
UV-B Damage





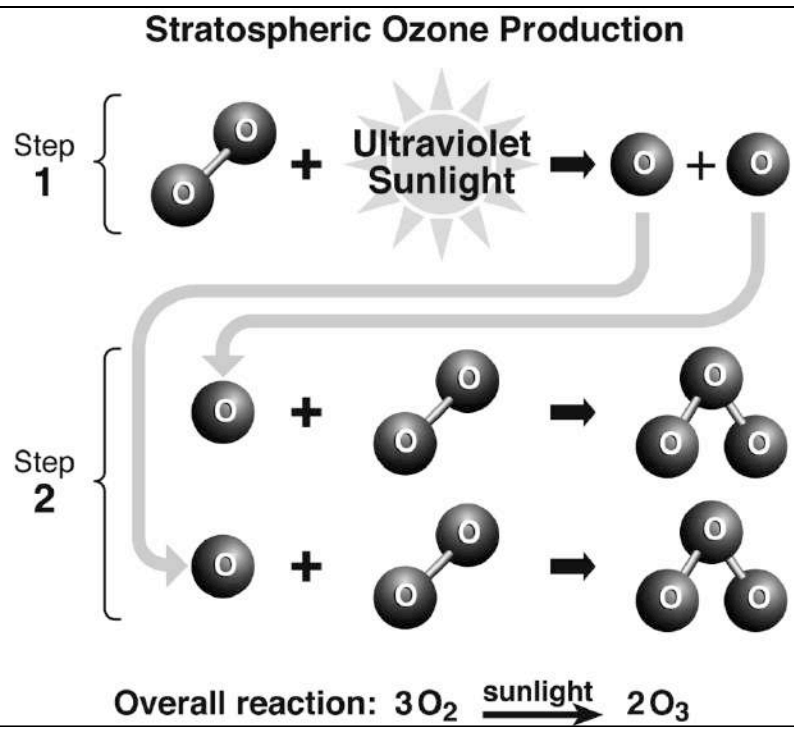
SKIN CANCER

CATARACT



Ozone Formation

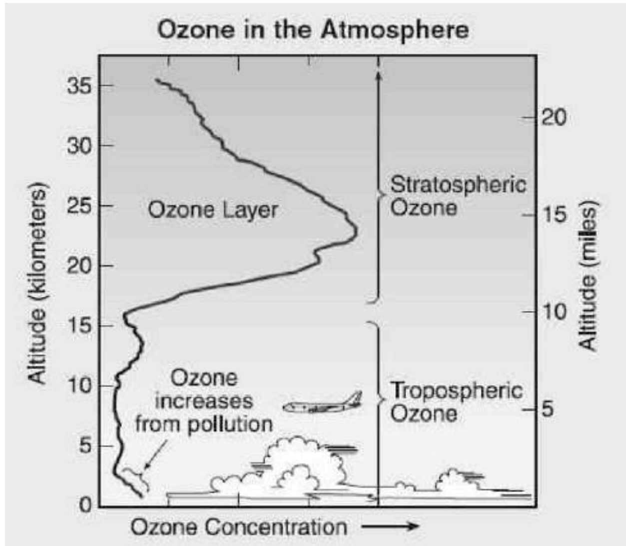
- Ozone (O_3) forms when oxygen (O_2) gas is exposed to UV radiation



Ozone Formation

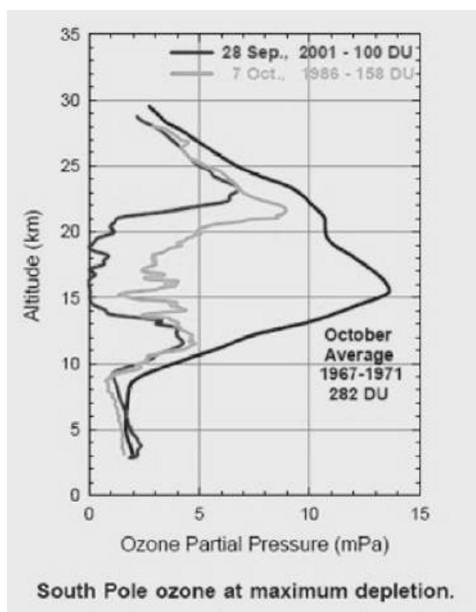
Ozone Depletion

- In October 1985, British scientists working in Antarctica reported data showing that the ozone layer was thinning.

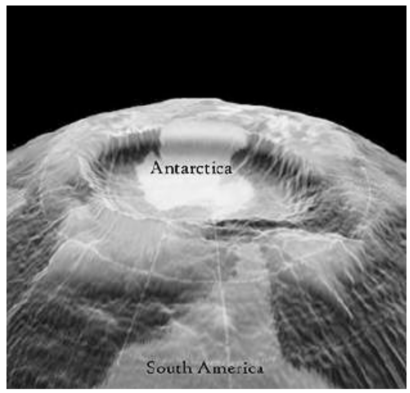


This graph shows normal ozone levels.

- The green line shows the ozone levels measured by the British scientists in 1986.



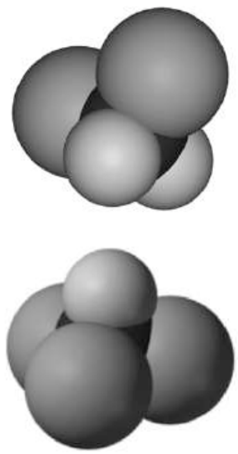
What could be causing the "ozone hole"?



A Tale of Two Chemicals

Part 2: Chlorofluorocarbons (CFCs)

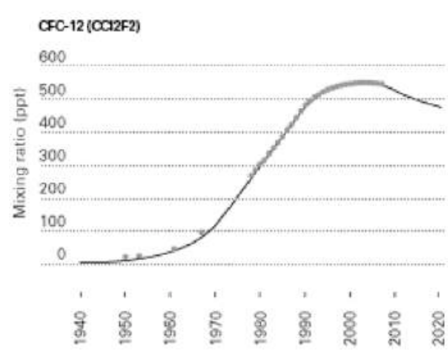
CFCs



- Group of compounds containing chlorine, fluorine, & carbon
- Used in refrigerators, air conditioning units, foam food and cup containers, and aerosol cans (as propellants)

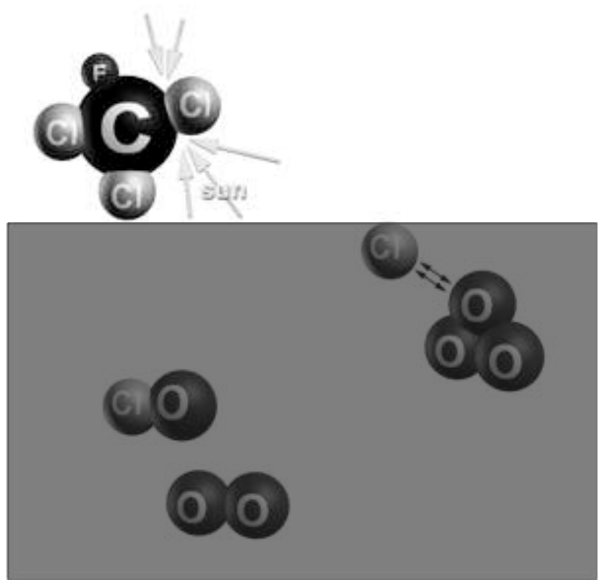
CFCs

- In the 1970s, scientists began to notice that the concentration of CFCs in the atmosphere was increasing



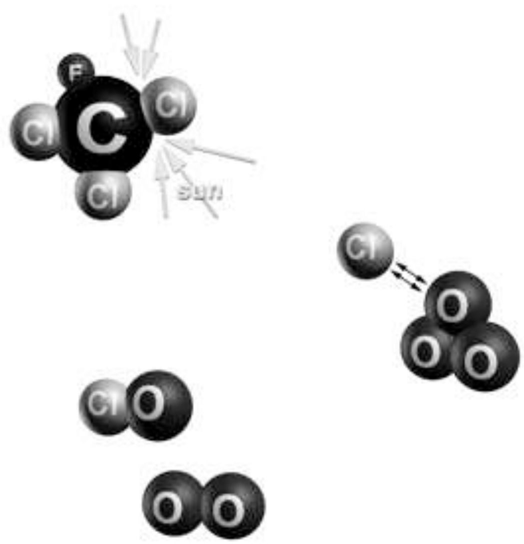
CFCs

- Chemists Mario Molina and F. Sherwood Rowland suggested that UV light could cause CFCs in the stratosphere to release a chlorine atom



CFCs

- Molina and Rowland hypothesized that the chlorine atom released from CFCs could attack and break down ozone



CFCs

- Molina & Rowland's model predicted that the chlorine atom formed by the breakdown of CFCs would react over and over again

–Click on the link below to view the entire process

View Glencoe video

CFCs

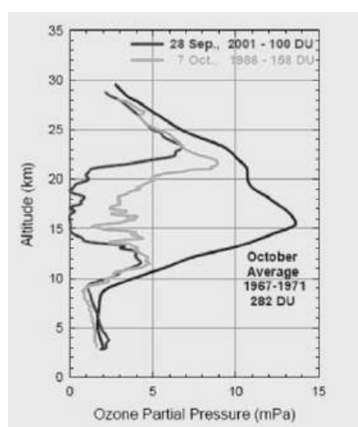
- Another research group found evidence of interactions between ozone and chlorine when taking measurements in the stratosphere
  - Did not know where chlorine was coming from
  - Molina & Rowland's model explained where the chlorine was coming from

▪View a NASA animation of CFCs depleting ozone on the next slide

Note that ozone is also depleted by nitrogen oxide molecules, which are pollutants in the atmosphere.

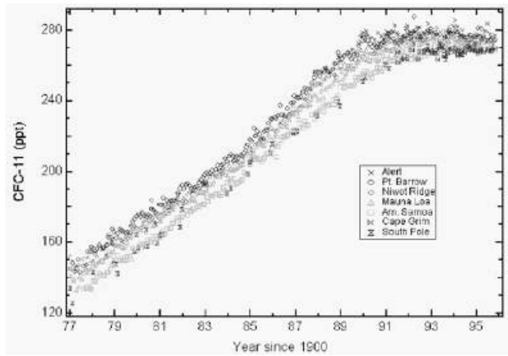
Ozone & CFCs

- In 1985, the ozone depletion announcement by the British Antarctic Survey supported Molina and Rowland's model



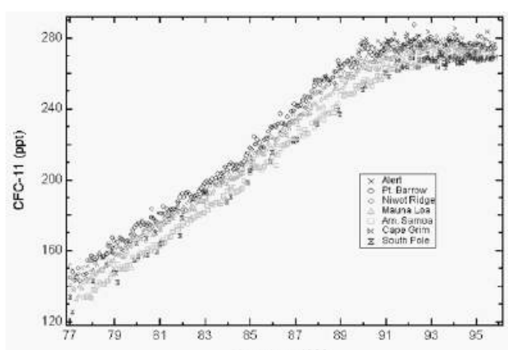
South Pole ozone at maximum depletion.

Ozone & CFCs



- In 1987, the Montreal Protocol was enacted, requiring that the production and consumption of CFCs be phased out by 2000

Ozone & CFCs



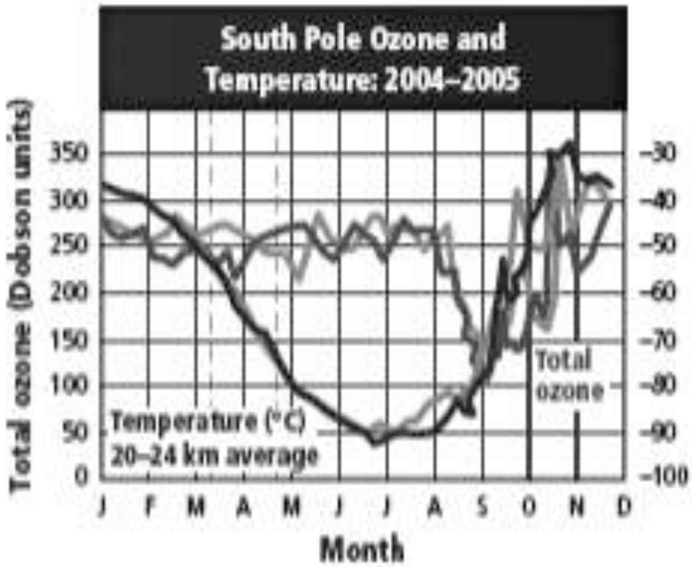
- Since then, CFC levels have begun to climb more slowly, level out, and decline

The Current Model

So, the "ozone hole" is fixed, right...?

Data Analysis Activity

- The National Oceanic and Atmospheric Administration (NOAA) continue to monitor the concentration of ozone in the stratosphere over Antarctica
  - The graph on the following slide displays data collected by NOAA in 2004 and 2005
    - Ozone levels are represented in blue
    - Average temperatures are represented in red
    - The 2004 data is represented by the lighter blue and red lines


South Pole Ozone and
Temperature: 2004–2005
Total ozone (Dobson units)
350
300
250
200
150
100
50
0
-30
-40
-50
-60
-70
-80
-90
-100
Temperature (°C)
Total ozone
Temperature (°C)
20–24 km average
J F M A M J J A S O N D
Month