Is the air always clear?

It’s so sunny and clear that you can see the buildings of the city miles away. Some days, however, you notice a brown fog hanging in the air over the buildings. What causes this brown fog to form? Substances released into the air can affect your health and the health of other organisms.

**Science Journal**  Write a paragraph describing three sources of air pollution.
Acid in Air
Pollutants from power plants and car exhaust can react with water in the atmosphere to produce acids. In this lab, you will determine if your region receives acidic precipitation.

1. Place a clean, glass jar outside before a rain or snow.
2. Bring the jar indoors. If you collected snow, let it melt.
3. Use a piece of pH paper or a computer probe to test the pH of the water.
4. If the pH value you obtained was less than about 5.6, your region receives acid rain.

Think Critically
Infer how air pollution in one region can cause acid rain hundreds of miles away.

Build Vocabulary
As you read the chapter, list the vocabulary words about air pollution on the tabs. As you learn the definitions, write them under the tab for each vocabulary word.

Air Pollution
Make the following Foldable to help you understand the vocabulary terms in this chapter.

STEP 1
Fold a vertical sheet of notebook paper from side to side.

STEP 2
Cut along every third line of only the top layer to form tabs.
What causes air pollution?

Nearly every organism depends on gases like oxygen in Earth’s atmosphere to carry out life functions. In addition to essential gases, the air you breathe also contains pollutants, which are harmful substances that contaminate the environment.

Air pollution comes from human activities as well as natural events. Industry, construction, power generation, transportation, and agriculture are a few examples of human activities that can pollute the air. Natural events that contribute to air pollution include erupting volcanoes that spew out ash and toxic gases. Kilauea Volcano on Hawaii is erupting and emitting toxic gases. People living downwind report having health problems. Smoke from forest fires and grass fires also can cause health problems.

Pollutants released directly into the air in a harmful form are called primary pollutants. Some examples of primary pollutants are shown in Figure 1. Pollutants that are not released directly into the air but form in the atmosphere are called secondary pollutants. Secondary pollutants are responsible for most of the brown haze, or smog, that you see near cities.

Figure 1  Primary pollutants include ash and toxic gases from volcanoes, soot from trucks, and smoke from industry smokestacks.
Smog

The term *smog* originally was used to describe the combination of smoke and fog, but the smog you see near cities forms in a different way. Smog near cities is called **photochemical smog** because it forms with the help of sunlight. Photochemical smog forms when vehicles, some industries, and power plants release nitrogen compounds and organic compounds into the air. These substances react to form nitrogen dioxide. The nitrogen dioxide then can react in the presence of sunlight to eventually form ozone, a secondary pollutant, as shown in Figure 2. Ozone is a major component of smog, and nitrogen dioxide is a reddish-brown gas that contributes to the colored haze.

**Reading Check** *How does photochemical smog form?*

**Nature and Smog** Nature can affect the formation of smog. In many cities, smog is not a problem because winds disperse the pollutants that cause smog to form. In some locations, however, landforms can add to smog development. Los Angeles, California, for example, is a city that lies in a basin surrounded by the Santa Monica Mountains to the northwest, the San Gabriel Mountains to the north and east, and the Santa Ana Mountains to the southeast. These surrounding mountains trap air in the Los Angeles region, preventing pollutants from being dispersed quickly. Los Angeles also frequently has sunny, dry weather. When nitrogen compounds are added to the air and exposed to sunlight for long periods of time, thick blankets of smog can develop.

**Figure 2** Pollutants from cars and other sources can cause urban smog.

**City Smog** Many large cities throughout the world have smog problems due to land forms, temperature inversions, population density and uncontrolled sources of pollution. Research how large cities in other countries, such as Mexico City, Mexico or Beijing, China protect people from smog.
Cool air usually overlies warm air near Earth’s surface. Pollutants can be carried away from their source.

During a temperature inversion, warm air overlies cool air, trapping air pollutants near the ground.

**Figure 3** A temperature inversion can worsen air pollution.

**Temperature Inversions** The atmosphere also can influence the formation of smog, as shown in **Figure 3**. Normally, temperatures in Earth’s lower atmosphere are warmest near Earth’s surface. However, a temperature inversion sometimes occurs. During an inversion, warm air overlies cool air, trapping the cool air near Earth’s surface. A temperature inversion reduces the amount of mixing in the atmosphere and can cause pollutants to accumulate near Earth’s surface.

**Reading Check** *What is a temperature inversion?*

### Acid Rain

Acids and bases are two terms that describe substances. A substance that is neither acidic nor basic is neutral. The pH scale, shown in **Figure 4**, indicates how acidic or how basic a substance is. A pH of 7 is neutral. Substances with a pH lower than 7 are acids. Substances with a pH above 7 are bases. Rainwater is naturally slightly acidic, but pollution sometimes can cause rainwater to be even more acidic.

Natural lakes and streams have a pH between 6 and 8. **Acid rain** is precipitation with a pH below 5.6. When rain is acidic, the pH of lakes and streams may decrease.

**Figure 4** Substances with a pH lower than 7 are acids. Those with a pH higher than 7 are bases. Rainwater naturally has a pH of about 5.6.
**Acid Rain Sources** Power plants burn fuels, like coal and oil, to produce the electricity that you need to light your home or power your stereo. Fuels also are burned for transportation and to heat your home. When fuels are burned, they release primary pollutants, such as sulfur dioxide and nitrogen oxides, into the air. These compounds rise into the atmosphere and combine with moisture in the air to form the secondary pollutants sulfuric and nitric acids.

Winds can carry acids long distances. The acids then can be returned to Earth’s surface in precipitation. Acid rain can discolor painted surfaces, corrode metals, and damage concrete structures.

**The Northeastern United States** As shown in Figure 5, precipitation in the northeastern United States is more acidic than in other areas. Sulfur dioxides and nitrogen oxides released from midwestern power plants and other sources are carried by upper-level winds blowing from a generally westerly direction. The resulting acids that form in the atmosphere eventually return to Earth as acid rain. Soils and rocks are naturally more basic in the midwest than in the northeastern United States. Therefore, acid rain falling in New York can decrease the pH of soils, streams, or lakes more so than acid rain falling in Indiana. Many lakes in the northeastern United States have few fish due to acid rain.

**Figure 5** The average pH of precipitation varies across the United States.
Particulate Pollution

Air contains suspended solid particles and liquid droplets called particulate matter. Some particles enter the air directly and are therefore primary pollutants, such as smoke from a fireplace or soot in bus exhaust. Other particles, such as liquid droplets, can form from gases such as nitrogen or sulfur oxides as they combine with water in the air.

Coarse and Fine Particulates Coarse particulate matter is carried in the wind from dusty, unpaved roads, construction sites, and land that has been cleared. You can see coarse particulate matter easily when a lot of it is in the air, but the individual size of each particle is only about one-seventh the diameter of a human hair, as shown in Figure 6.

Fine particulate matter is much smaller than coarse particulate matter—only about one-fourth the size of coarse particulates. Fine particulates are released into the air from fires, vehicle exhaust, factories, and power plants. Particulate matter can damage plants and buildings and harm your lungs.

Figure 6 Coarse particulate matter is about one-seventh the diameter of a human hair. Fine particulates are much smaller.

The average human hair is approximately 70 micrometers (0.000 07 m) in diameter.

Coarse particulate matter, like this house dust, ranges from 2.5 micrometers to 10 micrometers in diameter.

Fine particulate matter, like this soot, has a diameter less than 2.5 micrometers.
SECTION 1 Types and Causes of Air Pollution

Mobile sources (50%) include cars, trucks, and planes.

Area sources (24%) include businesses such as gas stations and dry cleaners.

Major sources (26%) include power plants and factories such as oil refineries and chemical manufacturers.

Figure 7 Toxic air pollution comes from factories, power plants, businesses, and transportation sources.

Toxic Pollutants and Carbon Monoxide

More than 180 different substances released into the air are called toxic air pollutants because they cause or might cause cancer or other serious human health problems. Toxic pollutants also can damage other organisms. Most of the toxic air pollution is released by human activities, like those in Figure 7. Some air toxins can be released from natural events such as fires and erupting volcanoes.

When fossil fuels are not completely burned, a gas called carbon monoxide forms. In a typical U.S. city, as much as 95 percent of this colorless, odorless gas comes from mobile sources. Concentrations of carbon monoxide increase when cars are stopped in traffic. Low levels of carbon monoxide can harm people with heart disease. Carbon monoxide is poisonous at high concentrations.

Chlorofluorocarbons

Since their discovery in 1928, people have been using chemicals called chlorofluorocarbons (KLOH urh floor oh kar buhns), or CFCs, in air conditioners, refrigerators, and aerosol sprays. For many years, CFCs were thought to be wonder compounds. They don’t burn. They’re easy to manufacture. They aren’t toxic. Millions of tons of CFCs were manufactured and sold by the mid-1970s. In 1974, scientists F. Sherwood Rowland and Mario Molina of the University of California began to wonder where all these CFCs ended up. They theorized that these compounds could end up high in Earth’s atmosphere and damage Earth’s ozone layer.
1. Compare and contrast primary and secondary air pollutants.

2. Explain what causes photochemical smog.

3. List sources of toxic air pollution and carbon monoxide.

4. Think Critically Why would Denver, Colorado, have smoggier air on some days than Portland, Oregon?

5. Solve One-Step Equations If a person breathes air each day that contains 0.000 03 g of particulate matter, how many grams of particulate matter would a person breathe in one year?
You know that strong winds can pick up and carry small particles such as silt from soil. However, particles also can be carried in air from a variety of sources on most any day. In this activity, you will examine particulates in the air.

**Real-World Question**

How much particulate matter is in the air? How do factors such as wind speed and location affect the amount of particulates?

**Goals**
- **Observe** particulates in the air.
- **Relate** particulate abundance to weather conditions and environment.

**Materials**
- vacuum cleaner
- paper filters (5)
- compass
- anemometer
- *coffee filter
- stereo microscope
- *local weather data source
- paper confetti
- *hand lens
- heavy-duty rubber bands (5)
- *alternative materials

**Safety Precautions**

**WARNING:** Do not use the vacuum cleaner in the rain or on a wet surface. Keep the cord away from moisture.

**Procedure**

1. Find an outdoor location in your schoolyard where electrical power is available.
2. Each day for five days, determine the wind direction and speed at your location. Wind direction can be determined by dropping confetti and using a compass to determine the direction from which the wind is blowing. Wind speed can be determined using an anemometer. Alternately, the information can be obtained from a frequently updated source of weather information. Also, record other weather conditions such as snow cover and whether it rained recently.
3. Wrap a large, paper filter around the intake hose of a vacuum cleaner. Fasten the filter to the hose by tightly wrapping it with a heavy-duty rubber band.
4. Turn the vacuum cleaner on and let it draw air at a height of about 1 m for 20 min. each day. You should use a different filter on each different day of your experiment.
5. Remove the filter and take it indoors. Draw a circle around the area where particles would have collected.
6. Examine the filter under a stereomicroscope. Count and describe any particles you observe.

**Conclude and Apply**

1. Describe the different types of particles collected on the filters.
2. Examine how wind conditions and other weather factors affected the number and type of particles collected each day.
3. Infer possible sources for the particles.
Air Pollution and Your Health

In the United States, more than 133 million people live in areas where air quality is unhealthy at times because of high levels of at least one pollutant. The United Nations estimates that at least 1.3 billion people around the world live in areas with dangerously polluted air.

The effects on your health from air pollution are listed in Figure 9. Health effects depend on how long you are exposed to the pollutant and how much of the pollutant is in the air. For example, you might notice watery eyes and shortness of breath on a smoggy day. When the air clears, you can breathe normally. If you breathe smoggy air for your entire life, you might have difficulty breathing when you get older.

Young children and elderly people suffer the most effects of pollution. With the same amount of exposure to pollutants, young children get much bigger doses for their size than adults do. When a child is young, all of his or her organs, including the brain, still are developing. Air pollution can affect the development of growing organs. Elderly people are at risk because they have been exposed to pollutants for a long time.
Smog and Carbon Monoxide  Compounds found in smog can cause your eyes to water and sting. Long-term exposure to smog can increase your risk for lung infections, reduce your ability to breathe normally, and might make asthma worse. You also can develop chest pains and a cough.

Carbon monoxide affects your blood’s ability to carry oxygen. High concentrations of this gas might affect your vision, your ability to concentrate, and your coordination. Very high levels can cause death.

Effects of Particulates and Toxic Pollutants  Do you sneeze when you shake out a dusty rug? When you sneeze, you force the dust out of your respiratory system. Smaller particles, however, can penetrate deep into your lungs and cause part of the lungs to become inflamed, as shown in Figure 10. Over time, small particulate matter might damage your lungs permanently, making breathing difficult and forcing your heart to work harder than it should.

Toxic substances in the air can damage many body systems. People exposed to toxic air pollutants can suffer from nerve damage, respiratory problems, and disorders of the reproductive system. They also can have an increased risk for cancer.

Exposure to a large amount of toxic air pollution over a short period of time can be deadly. On December 3, 1984, an accident at a pesticide factory in India released a cloud of toxic gas. More than 4,000 people died and 200,000 suffered permanent injuries such as blindness and heart disease.
Inhaling Acid

When you inhale humid air from acid rain, acid can be deposited deep inside your lungs. Acid irritates the lung’s sensitive tissues and reduces your ability to fight respiratory infections. Your lungs are responsible for moving oxygen into your blood. Damaged lungs cannot transfer oxygen to the blood easily, so the heart must work harder to pump oxygen to body cells. Over time, the heart can become stressed and weak.

Increased Ultraviolet Radiation

Harmful rays from the Sun, called ultraviolet radiation, are blocked partially by the protective ozone layer. Each spring, an ozone hole forms over Antarctica. The hole is an area of the ozone layer that is thinning. The size of the hole changes from year to year because of temperature variations in the atmosphere.

In humans, increased ultraviolet radiation is linked to skin cancer. One type of skin cancer, malignant melanoma, shown in Figure 11, accounts for only four percent of skin cancer cases but causes about 79 percent of skin cancer deaths. About 54,000 people are diagnosed with malignant melanoma in the United States each year, and nearly 7,600 people die from it. The number of new melanomas diagnosed has more than doubled since 1973.

In addition to skin cancer, cataracts are more common in people who are exposed to high amounts of ultraviolet radiation. Cataracts are a form of eye damage that make the lens of the eye cloudy. Ultraviolet radiation also can affect the immune system, which helps you fight illness.

What are some health effects of increased ultraviolet radiation?

You can protect yourself against excess ultraviolet radiation by avoiding outdoor activities during the middle of the day and by wearing long sleeves, a hat with a wide brim, sunglasses, and by using protective sunscreens.
Effects on Earth’s Organisms

Animals are exposed to air pollutants when they inhale gases and small particles. Because air pollutants fall to Earth in rain or snow, animals also are exposed when they ingest pollutants in their food and water. Soft-bodied animals such as earthworms, or animals with thin, moist skin, such as amphibians, can absorb air pollutants directly through their skin.

Just like humans, young animals are not able to tolerate the same amount of pollution as adult animals can. Whether or not an animal will be affected by a pollutant depends on the kind of pollutant, the length of time the animal is exposed to the pollutant, and the amount of pollutant taken into the animal’s body.

Concentrating Pollutants The concentration of a pollutant in the air might not be high enough to cause a problem. Some pollutants, however, stay in animal tissues instead of being excreted from their bodies as waste. When these animals are eaten by other animals, the pollutants are passed on to the predator. Biomagnification (BI oh mag nuh fuh KAY shun) is the process in which pollutant levels increase through the food chain, as shown in Figure 12. Some fish are not safe for humans to eat frequently because of biomagnification.

Figure 12 Pollutants from the air, such as the metal mercury, can end up in high concentrations in animals through biomagnification. Pollutants often are measured in parts per million, or ppm.
Acidic Lakes and Streams
Recall that lower pH means higher acidity. The pH of some streams, lakes, and rivers can decrease when acid rain falls. Many organisms require an environment with a narrow range of pH values.

In some streams and lakes in the United States and Canada, acid rain has eliminated certain fish species, such as brook trout. For example, hundreds of lakes in the Adirondack Mountains in New York are too acidic for the survival of fish. The Canadian government estimates that more than 14,000 lakes in eastern Canada are acidic. Acid rain is an even greater problem when snow melts. If a large amount of acidic snow falls in the winter and melts quickly in the spring, a sudden rush of acids flows into lakes and streams. Many fish and other organisms have been killed because of sudden pH changes.

Acid rain also can damage plants. At higher elevations, trees often are surrounded by fog. When the fog is acidic, trees suffer injury and are less able to resist pests and diseases. Some stands of evergreens in the Great Smoky Mountain National Park, as shown in Figure 13, have died from acidic exposure.

Acid Rain and Soils
Acid rain can also affect soils. As acid rain moves through soil, it can strip away many of the nutrients that trees and other plants need to grow. Some regions of the United States, however, have naturally basic soils. In such regions, acid rain might not significantly affect vegetation. The higher pH of basic soils can help raise the pH of acid rain after it falls to the ground.

Smog
The compounds in smog affect animals and plants. Smog affects the respiratory systems of animals, causing irritation to the lining of the lungs. When plants are exposed to smog over a long period of time, the pollutants break down the waxy coating on their leaves. This results in water loss through the leaves and increases the effects of diseases, pests, drought, and frost. Scientists estimate that smog formed from vehicle exhaust damages millions of dollars worth of crops in California each year.

What effects does smog have on plants and animals?
The Ozone Layer  As the ozone layer thins, Earth’s organisms are exposed to more ultraviolet radiation. Small organisms called phytoplankton (FI tuh PLANG tun) live in Earth’s freshwater and oceans. They make food using carbon dioxide and water in the presence of sunlight. These organisms also are the basis of the food chain shown in Figure 14. Research shows that ultraviolet radiation can reduce the ability of phytoplankton to make food, decreasing their numbers. Ultraviolet radiation also might damage young crabs, shrimp, and some fish. In some animal species, growth is slowed and the ability to fight diseases is reduced.

Ultraviolet radiation might affect many agricultural crops such as rice by decreasing the plant’s ability to fight diseases and pests. Even small increases in ultraviolet radiation might reduce the amount of rice grown per square kilometer. Rice is the main food source for more than half the world’s population. With world population increasing, a crisis might occur if rice and other crop production is affected by ultraviolet radiation.

How might increasing ultraviolet radiation affect world rice production?

Ozone depletion causes an increase in the amount of ultraviolet radiation reaching Earth’s surface.

Phytoplankton use the Sun’s energy to make food. Ultraviolet radiation weakens phytoplankton and affects how they reproduce.

Animal plankton eat phytoplankton. As phytoplankton numbers decrease, animal plankton populations will decrease.

Fewer animal plankton means less food for fish.

Figure 14  An increase in ultraviolet radiation could decrease the number of fish in antarctic waters.
**Air Pollution**

1. **Self Check**
   - List three ways that animals are exposed to air pollutants.
   - Summarize the effects of air pollution on human health.
   - Infer why young children are more affected by air pollutants than young adults are.
   - Think Critically What might happen to carbon dioxide levels in Earth’s atmosphere if ultraviolet radiation increases?

2. **Summary**
   - **Air Pollution and Your Health**
     - Smog can cause breathing problems.
     - Particulate pollution can damage your lungs.
     - Ultraviolet radiation is linked to skin cancer.
   - **Effects on Earth’s Organisms**
     - Biomagnification increases pollutants through the food chain.
     - Many lakes have no fish due to acid rain.
     - Smog can damage leaves, causing plants to lose water.
   - **Damage to Materials and Structures**
     - Structures require expensive cleaning because of soot and smoke.
     - Acid rain corrodes metals.

3. **Damage to Materials and Structures**
   Air pollution not only affects your health and the health of other organisms, it also damages many materials. For example, acid rain is known to corrode metals and deteriorate stone and paint. To reduce the damage on automobiles, some manufacturers use a very expensive, acid-resistant paint. Smoke and soot coat buildings, paintings, and sculptures, requiring expensive cleaning. In cities all over the world, works of art, ornate buildings and statues, and structures like the pyramids of Egypt, shown in Figure 15, suffer from the effects of air pollution.

4. **Figure 15** The pyramids in Egypt have withstood the Sun, wind, and sandstorms for more than 4,000 years. However, air pollution within the last 50 years has led to increased decay of these magnificent structures.
Clean Air Laws

Between 1900 and 1970, motor vehicle use and industrial manufacturing grew rapidly in the United States. Air in some parts of the country, especially in cities, became more polluted. Nitrogen oxides, which help form smog and acid rain, increased nearly 1,000 percent between 1900 and 1970.

Scientists and government officials recognized that air quality must be protected. Beginning in 1955, the U.S. Congress passed a series of laws to help protect the air you breathe. A summary of these laws is listed in Table 1. The U.S. Environmental Protection Agency has the responsibility of gathering and analyzing air pollution data from across the country and working to keep the country’s air clean.

The Clean Air Act is a federal law that regulates air pollution over the entire country. Each state is responsible for making sure that the goals of the law are met. State agencies limit what power plants and industries can release into the air. Companies that exceed air pollution limits might have to pay a fine. Automobile exhaust is monitored in areas with poor air quality.

<table>
<thead>
<tr>
<th>Name of Law</th>
<th>What It Does</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Pollution Control Act of 1955</td>
<td>It granted $5 million annually for air pollution research. Although it did little to prevent air pollution, the law made the public aware of pollution problems.</td>
</tr>
<tr>
<td>Clean Air Act of 1963</td>
<td>This act granted $95 million per year to state and local governments for research and to create air pollution control programs. It also encouraged the use of technology to reduce air pollution from cars and electric power plants.</td>
</tr>
<tr>
<td>Clean Air Act of 1970</td>
<td>It set standards for specific pollutants in the air and placed strict limits on car exhaust and pollutants from new industries.</td>
</tr>
<tr>
<td>Clean Air Act of 1990</td>
<td>This act placed strict limits on car emissions and encouraged the use of cleaner-burning gasoline. It also forced companies to reduce toxic emissions.</td>
</tr>
</tbody>
</table>
Ambient Air  You know that air pollutants released in one part of the country can affect the air somewhere else. Natural events, such as temperature inversions, can concentrate pollutants in an area. The surrounding air you breathe is called ambient (AM bee unt) air. Air pollution laws are written to help keep ambient air clean, no matter what the source of pollution is. Across the United States, scientists sample and test ambient air for particulate matter, carbon monoxide, sulfur dioxide, nitrogen dioxide, lead, and ozone. These pollutants cannot exceed a certain level, called an air quality standard. Areas that already have fairly clean air, such as national parks, have stricter air quality standards than cities do. As Figure 16 illustrates, if an area has pollution levels above ambient air quality standards, more controls can be placed on specific sources of air pollution.

Controlling the Source  Pollutants released into the air from a particular source are called emissions (ee MIH shunz). Emissions are measured at industry smokestacks and automobile tailpipes. If ambient air quality standards are not met, emissions must be reduced.

Emissions can be controlled in two ways—by using devices that capture pollutants already created and by limiting the amount of pollutants produced in the first place. For example, auto exhaust used to contain many more pollutants than it does today. Since 1975, each new car sold in the United States has been equipped with a catalytic (ka tuh LIH tihk) converter, a device that changes harmful gases in car exhaust to less harmful ones. A catalytic converter and other emission control devices are shown in Figure 17.

Changing the way gasoline is produced has helped control the amount of pollutants in gasoline even before it is burned. Compounds such as alcohol can be added to gasoline to reduce tailpipe emissions. Since the 1990 Clean Air Act was enacted, only clean-burning gasoline can be sold in the smoggiest areas of the country.
In the past few decades new technologies have reduced air pollution by trapping pollutants at their sources. Devices such as smokestack scrubbers, electrostatic precipitators, and catalytic converters shown here use different methods to remove pollutants from exhaust gases.

**SMOKESTACK SCRUBBER** Burning some types of coal to generate electricity produces large quantities of sulfur dioxide—a pollutant that can cause acid rain. The smokestacks of many coal-burning plants are equipped with anti-pollution devices called scrubbers.

**ELECTROSTATIC PRECIPITATOR** As smoke enters an electrostatic precipitator, plates that line the interior of the device give polluting particles a negative charge. Positively charged plates then attract the particles, “cleaning” the smoke. An electrostatic precipitator removes up to 99 percent of particulate matter from industrial emissions.

**CATALYTIC CONVERTER** Automobile exhaust gases pass over small beads coated with metals inside a catalytic converter. The metals cause chemical reactions that change most of the harmful gases into carbon dioxide and water.
Figure 18 Cars emit 0.6 g of nitrogen oxides per kilometer. Light trucks, minivans, and sport-utility vehicles can emit 1.1 g to 1.7 g per kilometer, depending on their size. Calculate How many grams of nitrogen oxides would not be emitted if you rode your bike for 5 km instead of riding in a car?

You Can Help

Laws and new technologies will help reduce air pollution, but you can be a part of the solution, too. When you reduce the amount of electricity you use, less fuel is burned at a power plant, and less pollution is released. Turn off lights and all appliances when you aren’t using them. Turn down the thermostat in the winter and wear more layers of clothing. Open windows in the summer instead of using air conditioning. Using public transportation, riding a bike, as shown in Figure 18, or car pooling will help keep the air clean.

How can you help reduce air pollution?

BURNING COAL Sulfur dioxide (SO₂) forms when coal or oil is burned. It is considered to be a major air pollutant. Burning a certain type of coal produces about 0.01 kg of SO₂ per kilogram of coal. If a power plant burns 3 million kg of coal annually, how much SO₂ would be released?

Solution

1. This is what you know:
   - production rate = 0.01 kg of SO₂/kg coal
   - annual coal use = 3,000,000 kg

2. This is what you need to find:
   - annual emissions = kilograms of SO₂ produced each year

3. This is the equation you need to use:
   - annual emissions = (annual use) × (production rate)
   - annual emissions = (3,000,000 kg coal) × (0.01 kg SO₂/kg coal) = 30,000 kg SO₂

4. Check your answer:
   - Divide your answer by the annual coal use. You should get the production rate for SO₂

Practice Problems

1. If a power plant burned 500,000 kg of coal annually, how much SO₂ would be produced?
2. If coal contained 0.02 kg of SO₂ per kg of coal, how much SO₂ would be produced if 250,000 kg of coal was burned?
SECTION 3 Solutions to Air Pollution

Improving Air Quality

As Figure 19 shows, air quality in the United States has improved since 1990, even though energy use increased and people are driving more. Strict controls on sources of pollution have greatly increased the quality of the air you breathe. Even so, although the national trends for most air pollutants are decreasing, some others, such as nitrogen dioxides, continue to rise. Smog levels are increasing in many rural areas, and haze is a problem in some national parks. The United States is home to more than 2,500 bodies of water whose fish are unsafe to eat because of biomagnification of toxins. As the United States population continues to increase, conservation and new technology can help reduce air pollution.

Figure 19 The total amount of air pollutants released to the air above the United States has decreased since the passage of strict air pollution laws.
Air Pollution Where You Live

**Real-World Question**

The quality of the air you breathe can affect your health and the health of other organisms near your home. Clean air laws passed in 1970 and 1990 have helped improve air quality in many regions of the United States. However, landforms and weather can affect air quality.

**Form a Hypothesis**

The air quality index tells you how clean the air is and whether it will affect your health. Some areas of the United States experience more air quality problems than others. Form a hypothesis about how weather conditions affect the air quality index.

**Make a Plan**

1. **Research** information about the air quality index. Data on the types of air pollutants collected by federal or state sources can be helpful.
2. **Research** specific weather data that can affect air pollution levels.
3. Investigate weather patterns that can contribute to an increase in the air quality index for a city or region.
4. Look for other types of information that provide additional clues about your community’s air quality. For example, do gasoline stations in your area have special equipment to prevent fumes from escaping while fueling your car?

**Goals**

- **Identify** the air quality index value and weather conditions for a city near you for a specified time period.
- **Evaluate** trends in weather patterns and air quality.
- **Draw conclusions** about how weather patterns affect air quality.

**Data Source**

Visit [in6.msscience.com/internet_lab](http://in6.msscience.com/internet_lab) to get more information about air quality and for data collected by other students.

<table>
<thead>
<tr>
<th>Air Quality</th>
<th>Air Quality Index</th>
<th>Protect Your Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>0–50</td>
<td>No health impacts occur.</td>
</tr>
<tr>
<td>Moderate</td>
<td>51–100</td>
<td>People with breathing problems should limit outdoor exercise.</td>
</tr>
<tr>
<td>Unhealthy for certain people</td>
<td>101–150</td>
<td>Everyone, especially children and elderly, should not exercise outside for long periods of time.</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>151–200</td>
<td>People with breathing problems should avoid outdoor activities.</td>
</tr>
<tr>
<td>Very Unhealthy</td>
<td>201–300</td>
<td>Health alert: everyone may experience more serious health effects.</td>
</tr>
<tr>
<td>Hazardous</td>
<td>&gt;300</td>
<td>Health warnings of emergency conditions.</td>
</tr>
</tbody>
</table>
Follow Your Plan
1. Make sure your teacher approves your plan before you start.
2. Create a table for your data.

Analyze Your Data
1. List the weather data and air quality index values you collected during the time period.
2. Compare and contrast weather data and the air quality index values.
3. Graph your data. You may want to show how temperature and the air quality index are related, or you may want to illustrate how values changed during the time period that you collected data.

Conclude and Apply
1. Evaluate Overall, how would you assess the quality of your community’s air?
2. Determine Is there a relationship between weather data and air quality data?
3. Discuss patterns in the air quality index over several days or weeks. For example, air quality may worsen from Monday to Friday. Explain why this might be happening.

Communicating Your Data
Find this lab using the link below. Post your data in the table provided. Compare your data to those of other students and plot the data on a graph. Present your findings to your class.
in6.msscience.com/internet_lab
How do you protect yourself from something you can’t see, smell, or taste? Years ago, the famous scientist Marie Curie frequently handled radioactive materials. Curie was investigating their properties, never realizing that the invisible rays emitting from the substances were slowly poisoning her. In 1934, she died of leukemia, which was most likely brought on by exposure to radiation.

Scientists eventually realized the danger of radioactive materials. Many workers in uranium mines developed lung cancer as a result of being exposed to radioactive substances. Scientists also learned that as uranium begins to break down, it changes into different elements, such as thorium, protactinium (pro tak THIH nee um), and radium... all still radioactive.

In 1900, a German scientist, Friedrich Ernst Dorn, discovered that radium emitted a radioactive gas called radon. Still, most people did not think radon gas was much to worry about.

All that changed in 1984. An engineer at a nuclear power plant in Pennsylvania set off the radiation detectors at the plant one morning. Officials found no contamination that could have caused this to happen. So, where did the engineer get his radioactive contamination? The answer was completely unexpected—the engineer’s home! The house had radiation levels 700 times higher than is considered to be safe for humans. Further study found that the house was built on rock that contained uranium and radon gas.

Fortunately, there are tests that people living in high-risk radon areas can conduct to detect levels of radon gas. And, if found, there are methods for removing radon gas from these buildings safely.
Reviewing Main Ideas

Section 1  Types and Causes of Air Pollution

1. Human activities and nature can cause air pollution.
2. Acid rain forms when compounds combine with moisture in the atmosphere.
3. Mountains, weather, and temperature inversions can add to smog development.
4. Toxic air pollutants come from vehicles, businesses, factories, power plants and volcanoes.

Section 2  Effects of Air Pollution

1. Depending on the exposure, smog, acid rain, and particulate pollution can cause minor discomfort or lead to long-term health problems.
2. Animals are exposed to air pollutants when they breathe polluted air. Some animals also can absorb pollutants through their skin.
3. The ozone layer protects Earth from ultraviolet radiation.
4. Pollutants can increase in concentration as they biomagnify through food chains.

Section 3  Solutions to Air Pollution

1. Air pollution laws passed since 1955 have reduced air pollution levels.
2. Catalytic converters on cars and smokestacks scrubbers help reduce air pollution.

Copy and complete the following chart on the health effects of air pollution.

![Health Effects Chart](image)
Use what you know about the listed terms to answer the following questions.


2. Why are emissions controlled when ambient air doesn’t meet an air quality standard?

3. Why didn’t the ozone layer immediately recover despite the severe restriction of chlorofluorocarbon use in the mid-1990s?

4. Explain how sulfur dioxide emissions in the Midwest contribute to acid rain in the Northeast.

5. How can biomagnification of toxic air pollutants occur in the environment?

6. What is the brown haze that forms over some cities called?

7. What is the pH of acid rain?

8. What does the ozone layer absorb?
   A) metals     C) acid rain
   B) UV radiation D) particulates

9. What type of pollutant is about one-seventh the diameter of a human hair?
   A) coarse particulate matter
   B) fine particulate matter
   C) acid rain
   D) carbon monoxide

10. Which term is used to describe increasing pollutant levels through the food chain?
    A) ambient     C) biomagnification
    B) emission    D) acidity

11. Most carbon monoxide pollution comes from which source?
    A) power plants
    B) cleaning products
    C) car exhaust
    D) industry

12. Which emission control device was added to automobiles in the mid-1970s?
    A) catalytic converter
    B) smokestack scrubber
    C) alcohol
    D) electrostatic separator

Use the figure below to answer question 13.

13. Which state has precipitation that is most acidic?
    A) California     C) Virginia
    B) Pennsylvania    D) Louisiana
14. Describe how traffic jams can increase air pollution.

15. Explain why air pollution affects the health of older people more than it affects most middle-aged people.

16. Infer why there are air quality standards for ambient air.

17. List three things you can do to help reduce air pollution.

18. Recognize Cause and Effect Why is the concentration of some pollutants greater in birds and mammals than in the contaminated organisms they eat?

19. Recognize Cause and Effect It has been sunny and hot with little wind for more than a week in your city. The newspaper reports that smog levels are unhealthy. Explain the connection.

20. Compare and contrast the effects of acid rain and ultraviolet radiation on organisms.

21. List some ways you can protect yourself against exposure to ultraviolet radiation.

22. Explain why air in some parts of the United States became more polluted from 1900 to 1970.

23. Recognize Cause and Effect After a quick spring thaw of heavy snow, many fish are found dead in a lake. Explain why this might happen.

24. Describe three kinds of air pollution caused by burning fuel in vehicles.

25. Explain how chlorofluorocarbon atoms in the atmosphere can increase ultraviolet radiation at Earth’s surface.

26. Explain how electrostatic precipitators remove particulate matter from smoke.

27. Research Information Research the pollutants found in cigarette smoke. Make a poster of how these substances harm your health.

28. Organize Activities To conserve energy in your school, place signs near light switches that remind people to turn off lights when they leave the room. Make signs encouraging students to carpool to school events.

29. Design and perform an experiment to test the effects of acid rain on plants. Remember to test one variable at a time.

30. Convert Units Most air pollutants are measured in micrograms. There are 1,000 micrograms in 1 milligram and 1,000 milligrams in 1 gram. How many micrograms are in 1 gram?

31. Decrease over Five Years Estimate the percent decrease in lead emissions from 1980 to 1985.

32. Decrease over Twenty Years Estimate the total decrease in lead emissions from 1980 to 2000.

Use the figure below to answer questions 31 and 32.

**Lead Emissions, 1980–2000**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons per year (thousands)</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: U.S. Environmental Protection Agency
The assessed Indiana standard appears above the question.

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Part 1 Multiple Choice

6.2.5

1. The graph below shows the amount of pollution released during three separate years.

How many more tons of particulate matter were released in 1985 than in 2000?

A 10,000 tons
B 15,000 tons
C 20,000 tons
D 30,000 tons

6.3.13

2. What is the reddish-brown gas that contributes to the colored haze of smog?

A carbon dioxide
B nitrogen dioxide
C oxygen
D ozone

6.3.16

3. Which are considered area sources of toxic air pollution?

A cars, trucks, and planes
B gas stations
C oil refineries
D power plants and factories

6.3.16

4. Using the graph above, which source emits the highest percentage of toxic air pollution?

A cars, trucks, and planes
B gas stations
C dry cleaners
D power plants and factories

Test-Taking Tip

Double-Check For each question, double-check that you are filling in the correct answer bubble for the question number you are working on.
5. The graph below shows a comparison of growth areas and pollution emission trends.

**Comparison of Growth Areas and Emission Trends**

<table>
<thead>
<tr>
<th>Year</th>
<th>Miles traveled</th>
<th>Energy use</th>
<th>Total pollution emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

What evidence supports the claim that use of catalytic converters has reduced automobile pollutant emissions?

A. Miles driven increased as energy use decreased.
B. Miles driven increased as energy use increased.
C. Miles driven increased as pollution emissions decreased.
D. Miles driven increased as pollution emissions increased.

6. Which gas is destroyed by chlorofluorocarbons?

A. carbon dioxide
B. nitrogen dioxide
C. oxygen
D. ozone

7. List some short-term health problems caused by polluted air. Who is most at risk for developing long-term effects?

8. How does acid rain form? What happens as acid rain soaks into and moves through soil?

9. The photo below shows Egyptian pyramids.

Describe possible causes of the weathering that can be seen in the photograph. How might the weathering seen in this photograph compare to weathering that can be seen on buildings near where you live?

10. Limestone is a rock that is basic in nature and is known for its ability to neutralize the effects of acid rain. How could limestone be implemented into a pollution reduction program?