ENERGY FOR EVERYONE
propane

Safety Considerations with Propane

LESSON 6
UNIT: PROPANE
PROBLEM AREA: PROPANE USE IN AGRICULTURE

Propane Education & Research Council

STUDENT LEARNING OBJECTIVES

Instruction in this lesson should result in students achieving the following objectives:

1. Outline safe work practices and equipment for propane.
2. Identify the parts of a propane cylinder and safety practices associated with their respective uses.
3. Identify the uses and describe the smell of propane odorant.
4. Identify the combustion properties of propane.
5. Describe the products of complete and incomplete combustion of propane.
6. Prescribe measures for accident prevention and procedures for emergencies.

NATIONAL SCIENCE STANDARDS ADDRESSED IN THIS LESSON

All students should develop an understanding of:

Physical Science: Content Standard B

- Chemical reactions
- Interactions of energy and matter

Life Science: Content Standard F

- Natural resources

LIST OF RESOURCES

The following resources may be useful in teaching this lesson:

- Propane.com
- Energy.gov
- EasternPropane.com
- GasCo-Propane.com
- NPGA.org
- OSHA.gov
- Propane101.com
- PropaneSafety.com

LIST OF EQUIPMENT, TOOLS, SUPPLIES, AND FACILITIES

- Propane scratch-and-sniff stickers. ***Note***: Hardcopy PERC pamphlets contain a scratch-and-sniff test to learn what propane smells like. **Tests can be purchased by calling PERC at 202-452-8975**.
- Empty propane tank
- Copies of sample test
- Visuals from accompanying masters
- Copies of student lab sheet

TERMS

The following terms are presented in this lesson *(shown in bold italics throughout the lesson):*

1. bottle
2. carbon monoxide
3. combustibility
4. complete combustion
5. cylinder
6. ethyl mercaptan
7. hydrocarbon
8. ignition temperature in air
9. incomplete combustion
10. limits of flammability
11. octane rating
12. odorant
13. reactants
14. regulator
15. safety relief valve (pressure relief valve)
16. shut-off valve
17. tank
18. tank gauge

TELL STUDENTS...

"We are going to look at some of the important safety considerations when using or working around fuel sources, specifically propane as an example of a hydrocarbon fuel. You should be able to outline safe work practices and measures for preventing and dealing with accidents when working with propane. We will also look in more detail at the odorant added to propane."

INTEREST APPROACH

Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible interest approach is included here.

THE SMELL OF PROPANE

1. Ask the students if they know what propane smells like. Have them try to describe the smell of propane.
2. Hand out propane scratch-and-sniff stickers for the students to smell. Ask students if the smell of propane was what they expected it to be. Discuss whether the students could have detected a propane leak had they not smelled the scratch-and-sniff stickers.
3. Emphasize the importance of recognizing the smell of propane in case of leaks. Explain that an odorant is added to propane for safety. Propane without the odorant is colorless and odorless.

Summary of Content and Teaching Strategies

OBJECTIVES 1 & 2

Objective 1: Outline safe work practices and equipment for propane.
Objective 2: Identify the parts of a propane cylinder and safety practices associated with their respective uses.

ANTICIPATED PROBLEM

Objective 1: What safe work practices and equipment are used with propane?

Objective 2: What safety practices are necessary when working with the various parts of a propane cylinder?

Propane safety demands special attention to both the work practices and the equipment used.

A. Propane is a liquid fuel that is stored under pressure. In most systems, propane is vaporized to a gas before it leaves the container. Propane is flammable when mixed with oxygen and can be ignited by many sources, including open flames, smoking materials, electrical sparks, and static electricity. As a result, it is important to follow safety measures when using or handling propane containers.
   1. Suppliers delivering propane or setting up appliances must be trained in the safe handling of propane.
   2. Nylon slings must be used in a "choker" manner when handling large propane tanks.
   3. Container valves and regulators are to be detached before moving containers.
   4. A crane hook must have a safety latch.
   5. Every commercial machine used to handle propane containers must be outfitted with a suitable fire extinguisher.
   6. Moving of nonconsumer, large propane containers should be done by technicians, except in emergencies.
   7. Propane containers should never be warmed in an effort to speed up the flow of gas.
   8. Propane cylinders should be secured in a vertical position.
   9. Propane containers should not be used without appropriate regulators.

B. Propane is usually stored in a tank, or cylinder. While every propane container is generally considered a ***tank***, the term ***cylinder*** usually refers to a container designed for personal use and transport (e.g., for machine operation, a grill, or a blowtorch).

C. Incorrect use of a transportable propane cylinder can be hazardous.
   1. A cylinder should never be handled or kept in an enclosed area.
   2. The ***shut-off valve*** should be tightly closed when the cylinder is not being used.
   3. Propane must not be kept or used near a heat source, because heat creates pressure inside the container. The ***safety relief valve (pressure relief valve)*** protects propane cylinders from over-pressurization. Excessive pressure can occur in the cylinder from an increase in temperature or from overfilling. The valve is typically a spring-loaded device with seals that prevent the internal cylinder pressure from rising above a predetermined level.
   4. Propane cylinders should be used, stored, or transported in a safe vertical position. In addition, cylinders should be stored outside, but not in direct sunlight.

D. The ***tank gauge*** indicates the amount of propane in the container; this is read as a percentage. For example, if the tank gauge reads 25, then one-fourth the propane (25 percent) is left.

E. When one is working with a new or reinstalled cylinder, these safety measures should be noted:
   1. **Regulator** — A ***regulator*** is essential when propane from a cylinder is being used.
      a. The regulator connector must be protected from damage. Leaky joints can result when the connector is damaged.

   b. The regulator vent should face downward, and the regulator should be sheltered. This stops ice from congesting the vent.
   c. The regulator vent must be kept clean and free of debris. Checking for obstructions to the vent (e.g., insects or nests) is important.
2. **Shut-Off Valve** – The ***shut-off valve*** is located at the top of the cylinder and is responsible for closing the flow of gas, especially in times of emergency. To shut the gas off completely, the valve will need to be turned to the right (clock-wise). A regulator is also used to control the flow of propane gas.
3. **Awareness Of Leaks** – One should always be observant for the smell of propane when in a spot where cylinders are located.

F. Transportation and storage:
   1. A cylinder should be transferred and kept in a secure and vertical position, which lets the pressure release valve stay in the cylinder's vapor room constantly.
   2. A cylinder should never be transported in the passenger side of any vehicle.
   3. A cylinder should never be transported without its valve having been shut off.
   4. A full cylinder should never remain inside a hot vehicle. Heat can cause the pressure relief valve to discharge propane.
   5. Propane cylinders should never be stored indoors, to include garages. The cylinders should be prevented from rolling or tumbling over.

G. Small cylinders are used in more applications than other sizes. The propane industry estimates that more than 80 million 20-pound cylinders are in circulation. Consequently, they are the primary source of propane emergencies. Typical portable cylinder applications include small hand torches, barbecue grills, agricultural weed burners, plumbers' melting pots, and recreational vehicles.

H. Despite that fact that manufacturers add an ***odorant*** to propane to alert customers to leaks, some people may have difficulty smelling it.
   1. It may be hard for some people to smell propane for the following reasons:
      a. They have a cold, allergies, sinus congestion, or another medical condition.
      b. Their sense of smell is reduced because of the use of tobacco, alcohol, or drugs.
      c. Tobacco smoke, cooking odors, and other strong odors can mask the smell of propane.
      d. As people age, their sense of smell can become less sensitive.
      e. If the smell of propane is present in the air over a period of time, "odor fatigue" can occur. The nose "gets tired," and a person no longer smells the propane odor.
      f. The propane smell may not be strong enough to wake up someone who is sleeping.
      g. The propane smell may be in a location (basement or attic) where it is not detected by people in other areas of the building.
      h. A phenomenon called "odor fade" can occur – an unintended reduction in the concentration of the odor of propane.
   2. Because some people may have difficulty smelling propane, a propane gas detector (listed by Underwriters Laboratories) may be purchased as an additional security measure. If the detector is installed and maintained consistent with the manufacturer's instructions, an alarm will sound if gas reaches the detector's sensor. Even if an alarm does not sound, the smell of propane should never be ignored.

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Begin the lesson with an interest approach, state the objectives, and introduce key terms.
2. Have the students read selections from appropriate resources.
3. Conduct a discussion about the uses of propane and how it is stored. Have students take notes.
4. Divide the class into small groups, and have them create posters that promote proper storage and transportation of propane cylinders.
5. Display an empty propane tank, and have students identify its parts and describe safety practices that accompany their respective uses.

OBJECTIVE 3

Identify the uses and describe the smell of propane odorant.

ANTICIPATED PROBLEM

What are the uses and smell of propane odorant?

Propane is colorless and odorless at the time it is produced. An ***odorant*** is added to warn consumers of a leak. ***Ethyl mercaptan*** is the odorant added to propane for safety purposes.

A. Ethyl mercaptan is not 100 percent effective.
    1. It can oxidize and lose its unique aroma, particularly if added to propane stored in steel containers that have been left open to the air.
    2. Not everyone can smell ethyl mercaptan.
    3. Odor fade also can diminish propane's smell. Odor fade is an unintended reduction in the concentration of the odor of propane, making it more difficult to smell. Although rare, several situations can cause odor fade:
        a. Air, water, or rust in a propane tank or cylinder can reduce propane odor concentration.
        b. If the propane is leaking underground, its passage through soil may reduce the smell of propane.
        c. The propane odor may stick to the inside surfaces of gas piping and distribution systems and possibly other materials.

B. The smell of propane with the odorant is most often described as rotten eggs, or skunk spray.

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Before revealing the information above, ask students to explain what they already know about propane odorant and its uses. Answers and discussion may vary widely but will help get students thinking about the subject.
2. Refer students back to Interest Approach 1, if used, or pass out the scratch-and-sniff stickers during this part of the lesson. After the students have smelled the propane odor, show **VM-A** to see if their reaction to smelling propane gas is the same as depicted in the image.

OBJECTIVE 4

Identify the combustion properties of propane.

ANTICIPATED PROBLEM

What are the combustion properties of propane?

The ***combustibility*** of propane is dependent upon the following characteristics:

A. ***Limits of Flammability*** – The percent of propane that must be present in a propane/air mixture for complete combustion to occur.

   1. ***Complete combustion*** results when all ***reactants*** (propane and air) are consumed during the reaction to produce carbon dioxide and water. The limits of flammability for propane are anywhere between 2.15 and 9.6 percent propane.
   2. An improper gas/air mixture can produce ***carbon monoxide*** (CO), a deadly product of ***incomplete combustion***.

B. ***Ignition Temperature in Air*** – temperature at which a substance will ignite without a spark or flame.

   1. Propane will ignite if it is heated to a temperature of 920°F to 1,020°F.
   2. Gasoline has an ignition temperature of approximately 495°F.
   3. Since the ignition temperature of propane is much higher than that of gasoline, propane is safer than gasoline and less likely to ignite.

C. ***Octane Rating*** – A fuel is a measure of its anti-knocking capacity in an internal-combustion engine, but it is also an indicator of how much compression is required for spontaneous combustion of the fuel to occur. Lower octane fuels would ignite with less compression and would be less safe. The octane rating of propane is 110; methane, 107; butane, 91; and gasoline, 87 to 93.

D. Source of Ignition – A propane/air mixture will not ignite unless the source of ignition reaches 920°F.

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Create a table on the board with the four combustion properties at the top. Have students take notes while you lead a discussion on the properties.
2. Divide students into teams of two or three. Have each team summarize the material for each property into one to three bulleted points.
3. Ask for volunteers to write the summaries on the board.
4. One of the most important points here is that the ignition temperature of propane (920°F) is higher than that of gasoline (495°F). Thus, in that respect, propane is safer than gasoline.

OBJECTIVE 5

Describe the products of complete and incomplete combustion of propane.

ANTICIPATED PROBLEM

What are the products of complete and incomplete combustion of propane?

A ***hydrocarbon*** is any organic compound made up of only hydrogen and carbon. Hydrocarbon fuels consist of chains of carbon and hydrogen atoms. To review, the molecular formulas for common hydrocarbons are:

- Methane (natural gas) – CH_4
- Ethane – C_2H_6
- Propane – C_3H_8
- Butane – C_4H_{10}

A. During ***complete combustion***, the two reactants – hydrocarbon fuel and oxygen – are consumed, yielding only carbon dioxide and water. Because of the high temperatures present during complete combustion of propane, water vapor is produced rather than water.

   Complete combustion of propane: $C_3H_8 + 5(O_2) = 3(CO_2) + 4(H_2O)$

B. During ***incomplete combustion***, an insufficient amount of oxygen is present for the reacting fuel to be completely consumed. As a consequence, carbon monoxide and carbon atoms are produced in addition to carbon dioxide and water.

   Incomplete combustion of propane: $C_3H_8 + 3.5(O_2) = CO_2 + CO + C + 4(H_2O)$

C. Carbon monoxide and safety

   1. ***Carbon monoxide*** (CO) is a very dangerous gas produced when any fuel burns. It cannot be tasted or smelled. High levels of CO can come from appliances that are not operating correctly or from a venting system or chimney that becomes blocked. CO can be deadly! High levels of CO can cause dizziness or sickness and, in extreme cases, can cause brain damage or death.
   2. Symptoms of CO poisoning include:
      a. Headache
      b. Shortness of breath
      c. Dizziness
      d. Nausea
      e. Fatigue
   3. Immediate action should be taken when physical symptoms of CO poisoning are noticed! This includes getting everyone out of the building and calling 911 or the local fire department. If it is safe to do so, windows should be opened to allow entry of fresh air, and any appliances suspected of releasing CO should be turned off. If no one has symptoms but the presence of CO is suspected, the propane retailer or a qualified service technician should be called to check CO levels and the propane equipment.
   4. The risk of CO poisoning can be reduced by:
      a. Having a qualified service technician check all propane appliances and related venting systems annually, preferably before the heating season begins
      b. Installing UL-listed CO detectors on every level of a house or other building
      c. Never using a gas oven or range-top burners to provide space heating
      d. Never using portable heaters indoors unless they are designed and approved for indoor use
      e. Never using a barbecue grill (propane or charcoal) indoors for cooking or heating
      f. Regularly checking all appliance exhaust vents for blockage

5. Signs of improper appliance operation that can generate high CO levels include:
    a. Formation of soot, especially on appliances and vents
    b. An unfamiliar or burning odor
    c. Increased moisture on the inside of windows

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Clearly explain to students the distinct difference between complete combustion and incomplete combustion and why understanding the difference is important.
2. Use **VM-B** to illustrate combustion. Have students take notes.

OBJECTIVE 6

Prescribe measures for accident prevention and procedures for emergencies.

ANTICIPATED PROBLEM

What are some measures for accident prevention and procedures for emergencies?

Knowing measures for accident prevention and procedures for emergencies is essential.

A. Prevention of propane accidents:
   1. One should be aware of the location of natural gas or propane lines, appliances, and tanks/cylinders and always be cautious when using them.
   2. Knowing where propane vapor may drift is important. Unlike natural gas, propane gas is heavier than air. When an accidental release of propane vapor occurs, the vapor will drift to the lowest spot (e.g., a basement). This can be particularly dangerous if there is a pilot light or other ignition source available.
   3. One should not interfere with a system's propane supply lines or appliances.
   4. One should not interfere with any safety apparatus, regulator, or storage container equipment.
   5. Knowing where to find the storage container's gas-service shut-off valve is important.
   6. Only skilled technicians should install or fix propane equipment.
   7. An open flame should never be used to check a propane leak.
   8. One should not attempt to light a pilot light that repeatedly goes out or is difficult to light.
   9. It is strongly recommended that only a qualified service technician light any pilot light that has gone out.

B. Emergency procedures for propane leaks:
   1. If one smells gas or suspects a gas leak, it is important to leave the area immediately. All smoking objects should be extinguished.
   2. Because any spark or flame near propane can ignite the gas:
      a. Electric switches should not be turned on or off.
      b. Matches should not be lit.
      c. A telephone should not be used.
   3. Everyone should be evacuated from the area.
   4. All gas-container supply valves should be shut off.
   5. From a neighbor's phone or nearby building away from the gas leak, the propane retailer should be called right away. If the propane retailer can't be reached, then 911 or the local fire department should be called.
   6. The trained technician or firefighters will check for runaway gas and then aerate the vicinity before allowing anyone to go back.
   7. The trained propane technician should:
      a. Fix the leak
      b. Check the pressure of the system
      c. Switch on the gas appliances
      d. Test all the gas appliances
      e. Relight the pilots on the appliances
   8. Persons should re-enter the area only when the technician or firefighters say that it is safe.
   9. Extinguishing media for propane fires include dry chemicals or CO_2 fire extinguishers. Surrounding areas should be sprayed with a water fog or spray.

C. The "Call Before You Dig" procedure is used to protect propane and other utility lines.
   1. A free safety service is available to any U.S. resident who plans to dig in a yard. A call to 811 will be directed to a local call center.
      a. Professional locators from utility companies will come to the residence and identify underground utility lines. The lines will be marked to prevent accidental damage when digging gets underway.
      b. Before any new digging project is started, 811 should be called, because erosion, root growth, etc., may have shifted the location of the utility lines.
   2. A propane tank is usually positioned outside the home or utility building in the yard, and supply lines are run underground from the tank to the building. A call to 811 should be made before digging around a propane tank.

SUGGESTED TECHNIQUES TO HELP STUDENTS MASTER THIS OBJECTIVE

1. Identify a representative from a local propane company who could speak with students about propane safety.
2. Conduct a discussion about propane accident prevention. Lead the students to identify measures for accident prevention.
3. Lead the students to identify the factors that make propane a potentially dangerous gas.
4. Use ***VM-C*** to illustrate what to do in an emergency.
5. Also, use ***VM-D*** to show how propane tanks and lines are laid out. Have students take notes during the discussion.

REVIEW/SUMMARY

Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. The anticipated problems can be used as review questions.

APPLICATION

Use the included visual masters to apply the information presented in the lesson. Note: Review LS-A. Do not leave students unattended during the laboratory.

EVALUATION

Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

ANSWERS TO SAMPLE TEST

Use the included lab sheets to apply the information presented in the lesson.

PART ONE: MATCHING

1. e
2. a
3. f
4. b
5. d
6. c

PART TWO: SHORT ANSWER

1. When propane is produced, it is colorless and odorless. The odorant ethyl mercaptan is added to propane to warn consumers of a prospective propane gas leak.
2. The four combustion characteristics of propane are limits of flammability, ignition temperature in air, octane rating, and source of ignition.
3. Incomplete combustion occurs when oxygen is insufficient to let the fuel (usually a hydrocarbon) completely react with oxygen to yield only carbon dioxide and water.
4. Deadly carbon monoxide can be produced. It is especially dangerous in an enclosed location.
5. Since propane gas is heavier than air, the vapor will drift to the lowest available spot when there is a leak.
6. Any spark or flame near propane can ignite the gas.

PART THREE: COMPLETION

1. technician
2. vehicle
3. secure, vertical
4. colorless, odorless
5. regulator
6. C_3H_8
7. carbon dioxide, water
8. open flame
9. shut-off valve
10. everyone, area
11. reactants
12. tank

NAME: _____

Safety Considerations With Propane

PART ONE: MATCHING

INSTRUCTIONS: Match the term with the correct definition.

a. ethyl mercaptan
b. incomplete combustion
c. hydrocarbon
d. cylinder
e. complete combustion
d. octane rating

_____ 1. A process that yields carbon dioxide and water vapor

_____ 2. The chemical odorant added to propane for detection

_____ 3. A rating of the anti-knock ability of a fuel

_____ 4. A process that yields water and carbon monoxide

_____ 5. A container for storing and transporting propane

_____ 6. An organic compound, of which propane is an example

PART TWO: SHORT ANSWER

INSTRUCTIONS: Provide a short written answer to the following questions.

1. Why is a chemical odorant added to propane?

2. What are the four combustion characteristics of propane?

3. When does incomplete combustion of propane occur?

4. Why is incomplete combustion so dangerous?

5. Why does propane gas always go to the lowest place?

6. When propane gas is present, why is it important to extinguish all smoking objects and open flames, not turn on light switches, not light matches, and not use a telephone?

PART THREE: COMPLETION

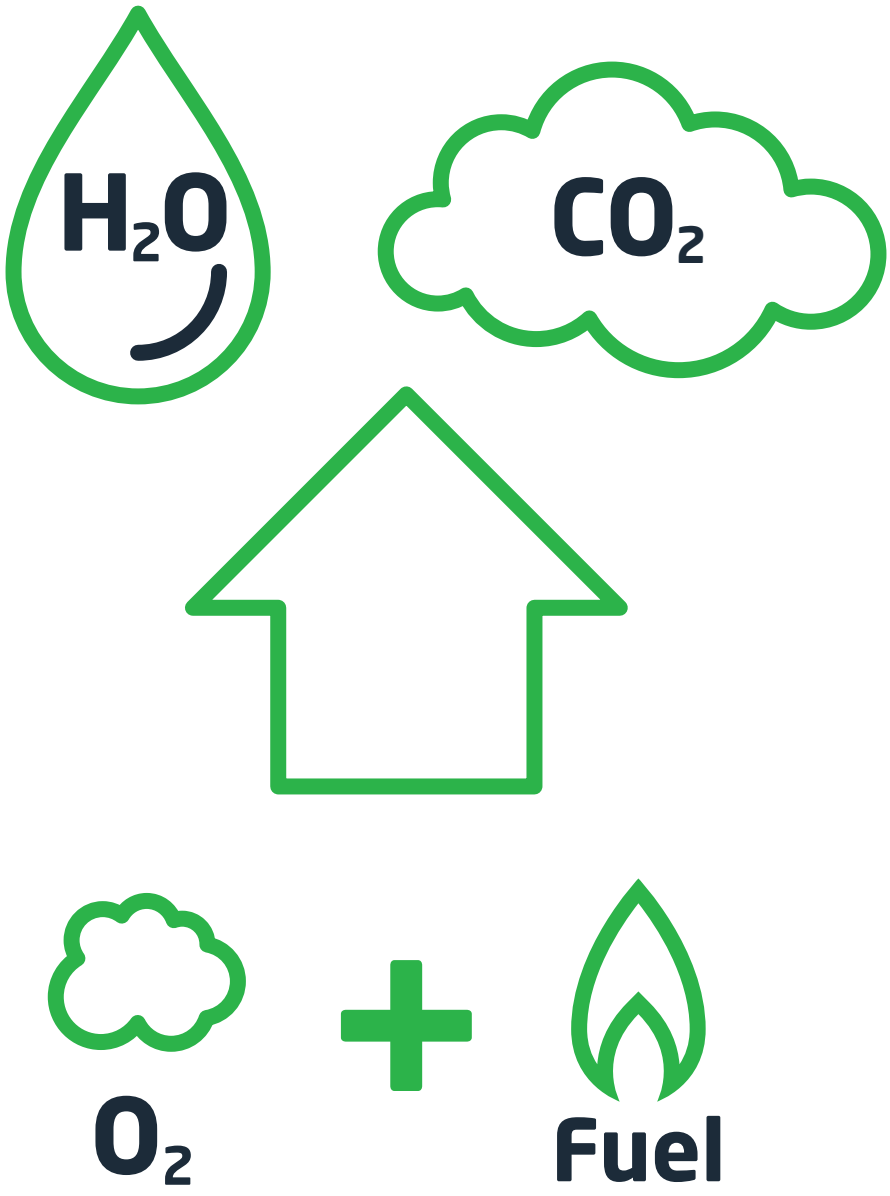
INSTRUCTIONS: Provide the word or words to complete the following statements.

1. Any moving of a propane container should be done by a _____ .
2. Never store a full propane cylinder inside a hot _____.
3. Always transfer and keep cylinders in a _____ and _____ position.
4. When propane is produced, it is _____ and _____.
5. A cylinder must be used with a _____ every time.
6. The molecular formula for propane is _____.
7. When a hydrocarbon burns in oxygen, the reaction will produce only _____ and _____.
8. Never use an _____ to check a propane leak.
9. A propane cylinder should have the _____ tightly closed when the cylinder is not in use.
10. During an emergency propane leak, immediately force _____ out of the _____.
11. Propane and oxygen are known as chemical _____.
12. Bottle, _____, and cylinder are all terms used to describe a propane container.

Propane Gas Odor Reaction

An odorant is added to propane to alert users of possible leaks. The smell is most often described as rotten eggs, skunk spray, or a dead animal.

Combustion



Emergency Procedures For Propane Leaks

- If one smells gas or suspects a gas leak, it is important to leave the area immediately. All smoking objects should be extinguished.
- Because any spark or flame near propane can ignite the gas:
  - Electric switches should not be turned on.
  - Matches should n ot be lit.
  - A telephone should not be used.
- Everyone should be evacuated from the area.
- All gas-container supply valves should be shut off.
- From a neighbor's phone or nearby building away from the gas leak, the propane retailer should be called right away. If the propane retailer can't be reached, then 911 or the local fire department should be called.
- The trained technician or firefighters will check for runaway gas and then aerate the vicinity before allowing anyone to go back.
- The trained propane technician should:
  - Fix the leak
  - Check the pressure of the system
  - Switch on the gas appliances
  - Test all the gas appliances
  - Relight the pilots on the appliances
- Persons should re-enter the area only when the technician or firefighters say that it is safe.
- Extinguishing media for propane fires include dry chemicals or CO2 fire extinguishers. Surrounding areas should be sprayed with a water fog or spray.

Propane Tank Installation

NAME: _____

How a Fire Extinguisher Works

PURPOSE

This lab will demonstrate that carbon dioxide is heavier than air and can extinguish a flame. The lab will also show how some types of fire extinguishers work. In this lab, you will mix vinegar and baking soda to produce CO_2. You will collect CO_2 off the top of the liquid/solid mixture and use it to put out a flame.

OBJECTIVE

Demonstrate that CO_2 can extinguish a flame.

MATERIALS

- Baking soda
- Candle
- Container at least 4 inches deep
- Matches or lighter
- Small cup
- Vinegar
- VM-E

PROCEDURE

1. Light the candle. Be careful when working with flames.
2. Pour baking soda into the large, clean container.
3. Gently pour some vinegar over the baking soda in the container. Pour enough to complete the fizzling and popping reaction. The reaction forms CO_2.
4. The CO_2 that will form from the mixing of the baking soda and the vinegar is colorless and odorless. Take the small cup and skim it over the top of the mixture. Do not collect any liquid or solid. You will be moving your cup through the layer of CO_2. CO_2 is heavier than air and is held in place by the sides of the container.
5. Take the small container and pour the CO_2 over the candle. The CO_2 in the container will put the flame out.
6. Write a lab report explaining what happened in this activity. Some things to include in the report are:
   - The title of the lab.
   - The objective of the lab. What were you trying to observe, create, or accomplish?
   - A summary of the procedures you followed.
   - An outline of what you observed. (There may be more than one observation.) Pay attention to color, odor, sound, etc. Is there a reason for the particular observation?
   - Your conclusion based on this activity.

How a Fire Extinguisher Works

IMPORTANT:
Do not leave students unattended during the laboratory.

Note that the reaction produces carbon dioxide. CO_2 is not combustible. CO_2 is heavier than other gases that make up the atmosphere. Nitrogen gas has an atomic weight of 30, O_2 has a weight of 32, and CO_2 has a weight of 44, so it sinks in the container holding the vinegar and baking soda mixture.

The CO_2 pours over the flame like water and extinguishes the candle.

Some fire extinguishers use compressed CO_2 to put out fires. The fires are surrounded by CO_2 and go out because of lack of oxygen.

Smothering A Flame With Co_2

1 Mix vinegar and baking soda

2 Scoop up CO_2

3 Pour CO_2 over candle

4 Flame extinguished