

States of Matter

Preparation

Grade Level: 3–6	Group Size: 25–30
Time: 50 minutes	Presenters: 3–5

Objectives:

The lesson will enable students to:

- Define three states of matter.
- Describe the characteristics of each state of matter.
- Provide examples of matter movement from one state to another.
- Identify carbon, oxygen, and hydrogen on the periodic table.

Standards:

This lesson aligns with the following National Science Content Standards:



- Physical science, grades K–8

Note: While we strive to make our lessons as safe as possible, there are risks inherent in using certain equipment or materials. Safety guidelines have been published where necessary within each lesson. Please ensure that you have adequately reviewed the lesson and have the information and materials necessary to perform it safely. Micron is not liable for any injuries that result from use of these lessons. Some of the equipment and materials used in the States of Matter lesson can pose a safety hazard if used incorrectly. Follow all safety guidelines and instructions as noted within the text of the lesson and with the materials provided in the kit to avoid potential injury.

Materials:

- “Characteristics of Solids, Liquids & Gases” poster – Appendix A
- “Energy Level” poster – Appendix B
- “Periodic Table” – Appendix C
- “Dry Ice and Water” worksheet – Appendix D
- “Dry Ice and Soap” worksheet – Appendix E
- “Dry Ice and Isopropyl Alcohol” worksheet – Appendix F
- “Dry Ice Worksheet Answers” – Appendix G
- Dry ice (about 3–5 lbs.)
- Hammer or rubber mallet
- Cloth for wrapping dry ice
- Oil
- Six beakers: 2–250 ml, 4–1 liter
- Tea candle
- Lighter/matches
- Food coloring

- Liquid soap
- 3' Plastic tube and stopper
- Isopropyl alcohol (rubbing alcohol)
- Large funnel
- Two large balloons or latex gloves
- Goggles or safety glasses
- Three pairs of leather gloves
- Tongs for picking up dry ice

Preparation

Set up each of the stations with the equipment needed.

Station One: Dry ice and water

Station Two: Dry ice and soap

Station Three: Dry ice and Isopropyl Alcohol

Ask the teacher to divide the class into three groups.

Glossary:

Melting:	Changing from a solid to a liquid state by application of heat or pressure or both.
Freezing:	Changing from the liquid to the solid state by loss of heat.
Boiling:	Generating bubbles of vapor when heated.
Vaporization:	Changing from a liquid to the gaseous state by the application of heat.
Condensation:	Changing from a gas or vapor to the liquid state.
Sublimation:	Changing from a solid to the gaseous state without passing through the liquid state.
Deposition:	Changing from a gas to the solid state without passing through the liquid state.
CO ₂ :	Carbon dioxide; a gas made up of one carbon atom and two oxygen atoms.
H ₂ O:	Water; a liquid made up of two hydrogen atoms and one oxygen atom. It can be a solid, liquid, or gas.



Caution: This lesson calls for the use of dry ice and isopropyl alcohol. Read through and follow the safety precautions as given below to avoid possible injury.

Safety Issues with Dry Ice

Handling

Dry ice is extremely cold. It freezes at -109.3°F (-78.5°C) and must be handled with care. Wear

leather gloves or oven mitts whenever handling it. If touched briefly, it is harmless; but prolonged contact will freeze cells and cause injury similar to a burn.

Burn Treatment

Treat dry ice burns in the same manner as heat burns. See a doctor if the skin blisters or comes off. If the skin only turns red, it will heal in time, similar to a sunburn or first degree burn. Apply antibiotic ointment to prevent infection and bandage only if the burned skin area needs to be protected.

Storage

It is important to follow these rules when storing dry ice:

- Store dry ice in an insulated container. The thicker the insulation, the slower the ice will sublimate.
- Do not store dry ice in a completely airtight container. The sublimation of dry ice to carbon dioxide gas will cause any airtight container to expand and possibly explode.
- Make sure the storage area is properly ventilated. Do not store dry ice in unventilated rooms, cellars, autos, or boat holds. The sublimated carbon dioxide gas will sink to low areas and replace oxygenated air. This could cause suffocation if breathed exclusively.
- Do not store dry ice in a refrigerator or freezer for a long period of time. The extreme cold temperature will cause your thermostat to turn off the freezer.

Ventilation

Normal air is composed of 78% nitrogen, 21% oxygen, and only 0.035% carbon dioxide. If the concentration of carbon dioxide in the air exceeds 5%, it can become toxic. Smaller concentrations can cause quicker breathing but otherwise are not harmful. However, people with respiratory conditions such as asthma may experience some discomfort at small concentrations. If dry ice has been in a closed vehicle, room, or walk-in for more than 15 minutes, open the doors and windows to allow adequate ventilation before you enter. If you are in an area that contains dry ice and start to pant and breathe quickly, leave immediately; you have inhaled too much CO₂ and not enough oxygen. Carbon dioxide is heavier than air and will accumulate in low spaces.

Transporting

Dry ice is available at most grocery stores. Obtain it as close to the time needed as possible. It sublimates at a rate of 10 percent or 5 to 10 pounds every 24 hours, whichever is greater. Carry it in a well-insulated container, such as an ice chest. If you transport it inside a car or van for more than 15 minutes, make sure the vehicle is well ventilated.

Disposal

Unwrap and leave the dry ice at room temperature in a well-ventilated area. It will sublimate

from a solid to a gas. Do not leave it on a tiled countertop as the extreme cold could crack the tile. Do not leave dry ice that is to be disposed of in an area where it could be mishandled.

DO NOT leave dry ice unattended around children.

Safety information adapted from <http://www.dryiceinfo.com/safe.htm>

To break the dry ice into usable pieces:

- Put on safety goggles to protect your eyes and leather gloves or oven mitts to protect your hands.
- Wrap the dry ice in a dishcloth and break it into approximately one-inch squares with a hammer or rubber mallet.

Safety Issues with Isopropyl Alcohol (IPA)

Isopropyl alcohol vapor is heavier than air and is highly flammable with a very wide combustible range. It should be kept away from heat and open flame. To avoid IPA poisoning, avoid ingestion, prolonged inhalation, or long term absorption. Use in well-ventilated areas and wear protective gloves while using.

Refer to <http://0-www.cdc.gov.mill1.sjlibrary.org/niosh/npg/npgd0359.html> for further information on the proper use of Isopropyl Alcohol.

Introduction

Begin the presentation with all of the students in a large group. Ask the following questions and allow enough time for the students to answer.

Q: What is a chemist?

A: A chemist is someone who studies chemistry.

Q: What is chemistry?

A: Chemistry is the study of matter.

Q: How would you define or describe matter?

A: Matter is anything that has mass (weighs something) and occupies space.

There are two types of change that can occur to matter: chemical and physical. Chemical change occurs when an object's original material changes into a different kind of material, for example: burning a match or baking a cake. Physical change results in a new form of the same material, examples include: ice melting, water boiling or freezing, steam condensing, and carbon dioxide sublimating. We are going to look at physical changes today.

Q: How many states of matter are there and what are they?

A: Matter is found in four different states: solid, liquid, gas and plasma. Each of these states is known as a phase. Today we will study the phases of solid, liquid and gas.

Use the Energy Levels poster to support the discussion on energy levels.

Elements and compounds can move from one phase to another phase when physical forces are applied. These physical forces either add or remove energy. Heat is one example of a physical force.

Q: How is heat measured?

A: Heat is measured by temperature.

Q: Is energy added or removed when temperature increases?

A: Energy is added when temperature increases.

Present to the class three different materials. Ask them to identify the state of matter for each material (rock, oil, inflated balloon). Use the poster, "Characteristics of Solids, Liquids, and Gases" (Appendix A) to support the discussion.

Q: What are the characteristics of a solid?

A: The characteristics of a solid are:

- Solids hold their own shapes (definite shape).
- Solids are hard to compress (definite volume).
- The atoms and molecules of solids are tightly packed.

Q: What are examples of solids?

A: Rocks, chairs, trees, books

Q: What are the characteristics of a liquid?

A: The characteristics of a liquid are:

- Liquids fill the shape of any container (indefinite shape).
- Liquids are hard to compress (definite volume).
- The atoms and molecules of a liquid tend to be a little more spread out than a solid, but much more compact than a gas.

Q: What are examples of liquids?

A: Oil, water, orange juice, syrup

Q: What are the characteristics of a gas?

A: The characteristics of gases are:

- Gases fill a container of any size or shape (indefinite shape).
- The volume of a gas is defined only by the size of its container (indefinite volume).
- The atoms and molecules of a gas are free to move around independently of one another.

Q: What are examples of gases?

A: Helium in balloons, air (nitrogen and oxygen).

Q: Think of a material, such as water. In what order does water move from one state to another?

A: Water can move from a solid, to a liquid, and then to a gas. It can also move from a gas to a liquid and then to a solid.

Q: Do you know of any materials that move from state to state in a different order?

A: Dry ice.

Dry Ice Sublimation Demonstration

Q: How does ice change state?

A: It goes from a solid to a liquid to a gas

Q: What do you think will happen when dry ice is placed on the counter?

A: It goes directly from a solid to a gas.

Have a student put on a pair of leather gloves and remove one piece of dry ice from the ice container and place it on the countertop.

Q: Describe what is happening.

A: The dry ice is sublimating and giving off a vapor (gas).

Q: Why isn't there a puddle, and how does that indicate what state was skipped?

A: There is no puddle because the liquid state was skipped.

Q: How is dry ice different than ice? What is dry ice?

A: Ice is frozen water (H₂O). Dry ice is frozen carbon dioxide (CO₂), the gas we exhale as we breathe. Identify carbon and oxygen on the periodic table. It is much denser and colder than ice. The temperature at which dry ice freezes is -109.3 °F (-78.5°C). Ice melts at 32°F (0°C). Dry ice doesn't melt; it sublimates. Sublimation is the process of going directly from a solid to a gas. Dry ice bypasses the liquid form. That's why we call it "dry" ice.

Have students observe the gas that comes from the dry ice.

Q: What direction does the gas move?

A: It moves downward.

Q: Why do you think the gas goes down instead of up, like steam?

A: This is due to two things:

- 1) The temperature difference between the dry ice and the air (cooler gas masses will sink)
- 2) The density of the CO₂ gas (CO₂ is heavier than air)

Candle/flame demonstration

Light a tea candle in the bottom of a 1-liter beaker.

Q: What do you think will happen when the dry ice is placed along side the candle in the bottom of the beaker?

A: Answers will vary.

Have a student place a piece of dry ice in the beaker using the leather gloves or tongs.

Q: The flame is extinguished. Why? Why can CO₂ be used to extinguish a fire?

A: CO₂ gas is heavier than air. The gas stays in the bottom of the beaker and displaces the oxygen, so that there is not enough oxygen to support combustion. CO₂ is the gas that humans breathe out, and plants and trees breathe in. It is the bubbles in our soda pop. CO₂ fire extinguishers are quite common.

A chemist asks a lot of questions: What? How? Why? Today you have an opportunity to be a chemist as you participate in three different activities. Ask what, how, and why about each of the activities in which you participate. You will have scientific data sheets to record the results of each of the experiments.

Divide the class into three groups and begin rotations.

Dry Ice and Water



Caution: Use proper handling techniques and provide adequate ventilation to avoid the risks involved with using dry ice. Make sure you have read the Dry Ice Safety Information on page 2 before doing this lesson station.



Fill a 250-ml beaker half full with warm or hot water.

Have students make predictions about what they think will happen when the dry ice is placed in the beaker of warm water and have them share their rationale for their predictions. Record their observations.

Instruct one student in the group to put on a pair of leather gloves or use the tongs to place a chunk of dry ice in the beaker of hot water. Establish with the students that the dry ice is shrinking.

Q: What is causing the water to bubble?

A: Guide the students to the fact that the water is not boiling, even though it is bubbling. The bubbles are created from the pressure of the CO₂ gas sublimating in the (H₂O) water. The gas coming off the top is not steam, like when a pot of water boils, but CO₂ gas.

Q: Why was the bubbling rapid at first and then slow?

A: The rate of bubbling slows as the water cools. Initially, the dry ice was sublimating at a rapid rate due to the extreme temperature difference between the dry ice and the water. As the water begins to cool and the temperature difference between the dry ice and water becomes smaller, the bubbling begins to slow.

Q: What happens as the water cools?

A: When the water cools enough, water ice will form a covering on the dry ice. The ice will even encapsulate the chunk of dry ice, then pop, as further sublimation takes place and CO₂ gas builds up inside the capsule of ice.

To prepare for the next student rotation, dump the contents of the 250-ml beaker into the 1 liter beaker and prepare for the next group.

Dry Ice and Water Extension – Measuring Temperature Change

Have the student experiment in a systematic manner by measuring the temperature change.

Give each group of students a thermometer and a beaker of water at room temperature.

Instruct the students to:

- Measure and record the temperature of the water before placing dry ice in the beaker.
- Add a cube of dry ice to the water.
- Measure the temperature of the water once every minute after the dry ice is added.
- Graph the change in temperature over time. The y-axis = temperature, x-axis = time.

Dry Ice and Soap



Caution: Use proper handling techniques and provide adequate ventilation to avoid the risks involved with using dry ice. Make sure you have read the Dry Ice Safety Information on page 2 before doing this lesson station.



Fill a 250-ml beaker half full with warm or hot water and add some liquid soap.

Have students make predictions about what they think will happen when the dry ice is placed in the beaker of soapy water. Then have the students share their rationale for their predictions. Record their observations.

Instruct one student in the group to put on a leather glove or use tongs to place a chunk of dry ice in the beaker of soapy water. Establish with the students that the dry ice is shrinking.

Q: What causes this physical reaction?

A: The dry ice is heated by the water causing it to sublime rapidly. The carbon dioxide gas becomes “trapped” in the soap that is dissolved in the water. If you pop the soap bubbles, the CO₂ gas will be released into the air.

Q: Why does the bubble tube move in a downward direction?

A: The bubble tube moves in a downward direction because CO₂ is heavier than the O₂ in the air, and because the bubbles are connected to each other.



If time allows, fill a 250-ml beaker half full with warm or hot water, add some liquid soap, and add a drop of food coloring.

Q: If we add food coloring to the water would the CO₂ be trapped in the bubbles or would the bubbles become the color of the food coloring?

A: *Have the students make predictions.* Neither the CO₂ nor the bubbles took on the color of the food coloring. The food coloring dissolved in the water but not in the dry ice or soap. And since the sublimation of the dry ice is a physical change and not a chemical change, the CO₂ remains unchanged. Likewise, the soap is not changed by the water so it does not “react” with the food coloring dissolved in the water.

To prepare for the next student rotation, dump the contents of the 250-ml beaker into the 1-liter beaker and prepare for the next group.

Dry Ice and Isopropyl Alcohol



Caution: Use proper handling techniques and provide adequate ventilation to avoid the risks involved with using dry ice and Isopropyl Alcohol. Make sure you have read the Dry Ice Safety Information on page 2, and the Isopropyl Alcohol Safety Information on page 4 before doing this lesson station.



Fill a plastic tube about 4–5 inches high with isopropyl alcohol.

Have students make predictions about what they think will happen when the dry ice is placed in the sealed test tube of isopropyl alcohol (rubbing alcohol) and have them share their rationale for their predictions. Record their observations.

Instruct one student in the group put on a leather glove or use the tongs to place a chunk of dry ice in the test tube. Place a stopper on the top opening of the tube and point it away from the any people.

Caution: Insure the tube is pointed away from people or breakable objects. The physical reaction will cause the stopper to be launched from the tube.

Q: What caused the physical reaction?

A: The isopropyl alcohol (rubbing alcohol) acts as a heat source because it is at room temperature (28° C) and dry ice is at -78° C. This heat speeds up the transition from solid to gas. In the tube, the gas builds up pressure and is pushing on all sides and ends of the tube. Finally, the gas builds up enough pressure to pop the stopper off.

Q: What could you do to increase the reaction time?

A: Warming the isopropyl alcohol would cause the dry ice to sublime faster, and would increase the reaction time.

Q: If you used water instead of isopropyl alcohol, why would it take longer for the stopper to pop off?

A: The increase in time is due to the water cooling down faster than Isopropyl alcohol, thus decreasing the heat provided to the dry ice, slowing the rate of sublimation. The slower the sublimation, the slower the evolution of gas, which is the force that pops the stopper.

Q: What is the effect of isopropyl alcohol compared to water in the plastic tube?

A: Due to differences in freezing points of isopropyl alcohol and water, water cools down much faster than isopropyl alcohol. This causes the stopper to take longer to pop off for each consecutive trial. Eventually, the water would freeze over. Since isopropyl alcohol has a lower freezing point -89.5°C , it does not freeze at the same temperature as dry ice.

To prepare for the next student rotation, dump the contents of the 250-ml beaker into the 1-liter beaker and prepare for the next group. At the end of the presentation the Isopropyl alcohol can be returned to the container or emptied into the drain.

Conclusion

Mystery Balloon/Rubber Glove

Q: From what you have learned, what do you think will happen when dry ice is placed a balloon or rubber glove? Why?

A: Answers will vary.

Place a few pieces of dry ice into the balloon or glove. Have one student hold the opening of the balloon or glove over the funnel and another student scoop dry ice into the funnel. Make sure each student wears leather gloves. After a few scoops of dry ice are funneled into the balloon or glove, tie it off.

Q: What is the mystery? How did the balloon/glove self inflate?

A: Dry ice doesn't melt, it just gets smaller. When the dry ice sublimates, large amount of gas are generated causing the inflation. Eventually the pressure of the gas becomes so great the balloon will burst. *(Hold the balloon away from your body and students).*

Concluding Questions

Q: How many states of matter are there?

A: Three states that were discussed today: Solid, liquid, gas. Plasma is an additional state that wasn't covered.

Q: Describe how elements move from one state to the next.

A: When energy is added or removed it moves from one state to another. It can also skip states.

Q: Give an example of material moving from one state to the next.

A: Water – ice to liquid to steam.

Q: What are the characteristics of a solid, liquid, and gas?

A: Review introduction for answers.

Chemistry is a lot like cooking. You mix chemicals together like you mix the ingredients in a recipe (flour, sugar, butter, milk) and then wait to see what happens.

Dry Ice Trivia

Q: How is dry ice made?

A: The first step in making dry ice is to turn the carbon dioxide gas into a liquid. This is done by compressing the CO₂ and removing any excess heat. The CO₂ will liquefy at a pressure of approximately 870 pounds per square inch. Next, the pressure is reduced further by sending the liquid carbon dioxide through an expansion valve. Part of the liquid sublimates, causing the remainder to freeze into snowflakes. The dry ice snow is then compacted together under a large press to form blocks. Dry ice is much heavier than traditional ice, weighing about the same as standard bricks.

Additional Information:

The Fourth State of Matter

Scientists also recognize a fourth state of matter that is plasma.

Q: What is plasma?

A: Plasma has properties similar to a gas except that it is composed of charged particles, called ions, which dramatically respond to electric and magnetic forces. Plasma has the highest energy of all the states of matter.

Q: Where can you find plasma?

A: Surprisingly, plasma is probably the most prevalent state of matter in the universe. Materials in the plasma state include flames, the outer portion of the earth's atmosphere, the atmosphere of stars including the sun, much of the material of nebular space, and part of a comet's tail. The aurora borealis is matter in the plasma state streaming through a magnetic field. Closer to home, plasmas are found in florescent lights, neon signs, and lightening.

Q: Where can I find more information on plasmas?

A: More information on plasma can be found by contacting The Division of Plasma Physics of the American Physical Society.

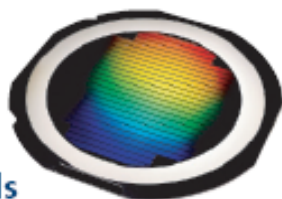
Resources: <http://www.plasmacoalition.org/edmaterials.htm>

Call toll free 1-877-PLASMAS

E-mail CPS@plasmacoalition.org

States of Matter

Characteristics of solids, liquids, and gases



Solids

- Solids hold their own shape (definite shape)
- Solids are hard to compress (definite volume)
- The atoms and molecules are tightly packed



Liquids

- Liquids fill the shape of any container (indefinite shape)
- Liquids are hard to compress (definite volume)
- The atoms and molecules tend to be a little more spread out than a solid, but much more compact than a gas

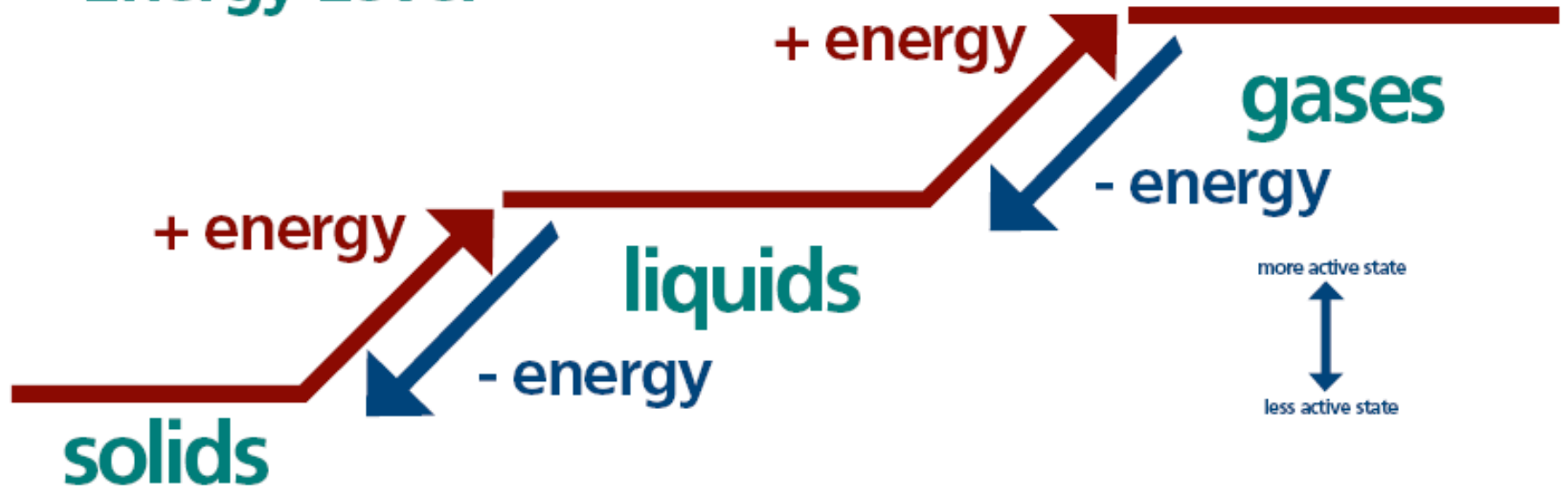


Gases

- Gases fill a container of any size or shape (indefinite shape)
- The volume is defined only by the size of its container (indefinite volume)
- The atoms and molecules are free to move around independently from one another

States of Matter

Energy Level



Appendix C – States of Matter

GROUP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
	IA	IIA	IIIB	IVB	VB	VIB	VIIIB	VIIIIB			IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA	VIIIA

PERIOD	1	2	3	4	5	6	7	
1	1 H Hydrogen 1706 1.0074 (1.00784 - 1.00710) Gas	2 He Helium 1869 4.0026 (4.00260325415 - 4.00260325415) Gas	3 Li Lithium 1817 6.941 (6.941 - 6.941) Solid	4 Be Beryllium 1798 9.01218 (9.012182 - 9.012182) Solid	11 Na Sodium 1807 22.98977 (22.98976928 - 22.98976928) Solid	12 Mg Magnesium 1808 24.305 (24.30469 - 24.30469) Solid	19 K Potassium 1807 39.0983 (39.09831 - 39.09831) Solid	20 Ca Calcium 1805 40.5 (40.078 - 40.078) Solid
2	3 Li Lithium 1817 6.941 (6.941 - 6.941) Solid	4 Be Beryllium 1798 9.01218 (9.012182 - 9.012182) Solid	11 Na Sodium 1807 22.98977 (22.98976928 - 22.98976928) Solid	12 Mg Magnesium 1808 24.305 (24.30469 - 24.30469) Solid	19 K Potassium 1807 39.0983 (39.09831 - 39.09831) Solid	20 Ca Calcium 1805 40.5 (40.078 - 40.078) Solid	37 Rb Rubidium 1861 85.467 (85.4678 - 85.4678) Solid	38 Sr Strontium 1790 87.62 (87.62 - 87.62) Solid
3	11 Na Sodium 1807 22.98977 (22.98976928 - 22.98976928) Solid	12 Mg Magnesium 1808 24.305 (24.30469 - 24.30469) Solid	19 K Potassium 1807 39.0983 (39.09831 - 39.09831) Solid	20 Ca Calcium 1805 40.5 (40.078 - 40.078) Solid	37 Rb Rubidium 1861 85.467 (85.4678 - 85.4678) Solid	38 Sr Strontium 1790 87.62 (87.62 - 87.62) Solid	55 Cs Cesium 1860 132.9054 (132.905451961 - 132.905451961) Solid	56 Ba Barium 1808 137.33 (137.327 - 137.327) Solid
4	11 Na Sodium 1807 22.98977 (22.98976928 - 22.98976928) Solid	12 Mg Magnesium 1808 24.305 (24.30469 - 24.30469) Solid	19 K Potassium 1807 39.0983 (39.09831 - 39.09831) Solid	20 Ca Calcium 1805 40.5 (40.078 - 40.078) Solid	37 Rb Rubidium 1861 85.467 (85.4678 - 85.4678) Solid	38 Sr Strontium 1790 87.62 (87.62 - 87.62) Solid	55 Cs Cesium 1860 132.9054 (132.905451961 - 132.905451961) Solid	56 Ba Barium 1808 137.33 (137.327 - 137.327) Solid
5	37 Rb Rubidium 1861 85.467 (85.4678 - 85.4678) Solid	38 Sr Strontium 1790 87.62 (87.62 - 87.62) Solid	55 Cs Cesium 1860 132.9054 (132.905451961 - 132.905451961) Solid	56 Ba Barium 1808 137.33 (137.327 - 137.327) Solid	87 Fr Francium 1939 223 (223 - 223) Solid	88 Ra Radium 1910 226.0254 (226.0254 - 226.0254) Solid	103 Lr Lawrencium 1961 260 (260 - 260) Solid	104 Rf Rutherfordium 1969 261 (261 - 261) Solid

5 B Boron 1808 10.811 (10.811 - 10.811) Solid	6 C Carbon 1772 12.011 (12.011 - 12.011) Solid	7 N Nitrogen 1774 14.007 (14.007 - 14.007) Gas	8 O Oxygen 1774 15.9994 (15.9994 - 15.9994) Gas	9 F Fluorine 1800 18.998403 (18.998403253 - 18.998403253) Gas	10 Ne Neon 1869 20.17 (20.1797 - 20.1797) Gas	15 P Phosphorus 1869 30.97376 (30.973761998 - 30.973761998) Solid	16 S Sulfur 1771 32.06 (32.06 - 32.06) Solid	17 Cl Chlorine 1774 35.453 (35.453 - 35.453) Gas	18 Ar Argon 1869 39.948 (39.948 - 39.948) Gas	21 Sc Scandium 1879 44.9559 (44.95591224 - 44.95591224) Solid	22 Ti Titanium 1791 47.88 (47.88 - 47.88) Solid	23 V Vanadium 1800 50.9415 (50.9415 - 50.9415) Solid	24 Cr Chromium 1797 51.996 (51.9961 - 51.9961) Solid	25 Mn Manganese 1774 54.938 (54.9380451 - 54.9380451) Solid	26 Fe Iron 1781 55.845 (55.845 - 55.845) Solid	27 Co Cobalt 1757 58.9332 (58.9332 - 58.9332) Solid	28 Ni Nickel 1751 58.71 (58.71 - 58.71) Solid	29 Cu Copper 1751 63.546 (63.546 - 63.546) Solid	30 Zn Zinc 1748 65.38 (65.38 - 65.38) Solid	31 Ga Gallium 1825 69.723 (69.723 - 69.723) Solid	32 Ge Germanium 1857 72.64 (72.64 - 72.64) Solid	33 As Arsenic 1817 74.9216 (74.9216 - 74.9216) Solid	34 Se Selenium 1817 78.96 (78.96 - 78.96) Solid	35 Br Bromine 1826 79.904 (79.904 - 79.904) Liquid	36 Kr Krypton 1898 83.8 (83.8 - 83.8) Gas						
39 Y Yttrium 1794 88.9059 (88.9059 - 88.9059) Solid	40 Zr Zirconium 1789 91.22 (91.224 - 91.224) Solid	41 Nb Niobium 1801 92.9064 (92.9064 - 92.9064) Solid	42 Mo Molybdenum 1778 95.94 (95.94 - 95.94) Solid	43 Tc Technetium 1844 98.9062 (98.9062 - 98.9062) Solid	44 Ru Ruthenium 1844 101.07 (101.07 - 101.07) Solid	45 Rh Rhodium 1803 102.9055 (102.9055 - 102.9055) Solid	46 Pd Palladium 1803 106.4 (106.4 - 106.4) Solid	47 Ag Silver 1774 107.8682 (107.8682 - 107.8682) Solid	48 Cd Cadmium 1817 112.411 (112.411 - 112.411) Solid	49 In Indium 1863 114.818 (114.818 - 114.818) Solid	50 Sn Tin 1781 118.710 (118.710 - 118.710) Solid	51 Sb Antimony 1781 121.757 (121.757 - 121.757) Solid	52 Te Tellurium 1782 127.6 (127.6 - 127.6) Solid	53 I Iodine 1811 126.905 (126.905 - 126.905) Solid	54 Xe Xenon 1898 131.29 (131.29 - 131.29) Gas	71 Lu Lutetium 1907 174.967 (174.967 - 174.967) Solid	72 Hf Hafnium 1923 178.49 (178.49 - 178.49) Solid	73 Ta Tantalum 1802 180.947 (180.947 - 180.947) Solid	74 W Tungsten 1783 183.85 (183.85 - 183.85) Solid	75 Re Rhenium 1925 186.207 (186.207 - 186.207) Solid	76 Os Osmium 1804 190.2 (190.2 - 190.2) Solid	77 Ir Iridium 1804 192.22 (192.22 - 192.22) Solid	78 Pt Platinum 1785 195.084 (195.084 - 195.084) Solid	79 Au Gold 3000 BC 196.9665 (196.96657 - 196.96657) Solid	80 Hg Mercury 1781 200.59 (200.59 - 200.59) Liquid	81 Tl Thallium 1861 204.37 (204.37 - 204.37) Solid	82 Pb Lead 1781 207.2 (207.2 - 207.2) Solid	83 Bi Bismuth 1785 208.9804 (208.9804 - 208.9804) Solid	84 Po Polonium 1900 209 (209 - 209) Solid	85 At Astatine 1940 210 (210 - 210) Solid	86 Rn Radon 1898 222 (222 - 222) Gas
103 Lr Lawrencium 1961 260 (260 - 260) Solid	104 Rf Rutherfordium 1969 261 (261 - 261) Solid	105 Db Dubnium 1970 262 (262 - 262) Solid	106 Sg Seaborgium 1974 263 (263 - 263) Solid	107 Bh Bohrium 1976 264 (264 - 264) Solid	108 Hs Hassium 1984 265 (265 - 265) Solid	109 Mt Meitnerium 1982 266 (266 - 266) Solid	110 Ds Darmstadtium 1994 267 (267 - 267) Solid	111 Rg Roentgenium 1994 268 (268 - 268) Solid	112 Uub Ununbium 1996 269 (269 - 269) Solid	113 Uut Ununtrium 2004 270 (270 - 270) Solid	114 Uuq Ununquadium 1996 271 (271 - 271) Solid	115 Uup Ununpentium 2004 272 (272 - 272) Solid	116 Uuq Ununquadium 1996 273 (273 - 273) Solid	117 Uuh Ununheptium 2000 274 (274 - 274) Solid	118 Uus Ununoctium 2000 275 (275 - 275) Solid	119 Uuo Ununoctium 2000 276 (276 - 276) Solid															

67 La Lanthanum 1839 138.905 (138.905 - 138.905) Solid	68 Ce Cerium 1803 140.12 (140.12 - 140.12) Solid	69 Pr Praseodymium 1839 140.9077 (140.9077 - 140.9077) Solid	70 Nd Neodymium 1829 144.24 (144.24 - 144.24) Solid	71 Pm Promethium 1945 145 (145 - 145) Solid	72 Sm Samarium 1879 150.4 (150.4 - 150.4) Solid	73 Eu Europium 1901 151.96 (151.96 - 151.96) Solid	74 Gd Gadolinium 1840 157.25 (157.25 - 157.25) Solid	75 Tb Terbium 1843 158.9254 (158.9254 - 158.9254) Solid	76 Dy Dysprosium 1826 162.5 (162.5 - 162.5) Solid	77 Ho Holmium 1878 164.9304 (164.9304 - 164.9304) Solid	78 Er Erbium 1843 167.26 (167.26 - 167.26) Solid	79 Tm Thulium 1879 168.9342 (168.9342 - 168.9342) Solid	80 Yb Ytterbium 1878 173.04 (173.04 - 173.04) Solid
88 Ac Actinium 1899 227 (227 - 227) Solid	90 Th Thorium 1828 232.0381 (232.0381 - 232.0381) Solid	91 Pa Protactinium 1917 231.0369 (231.0369 - 231.0369) Solid	92 U Uranium 1789 238.0289 (238.0289 - 238.0289) Solid	93 Np Neptunium 1940 237.0482 (237.0482 - 237.0482) Solid	94 Pu Plutonium 1940 244 (244 - 244) Solid	95 Am Americium 1945 243 (243 - 243) Solid	96 Cm Curium 1944 247 (247 - 247) Solid	97 Bk Berkelium 1949 247 (247 - 247) Solid	98 Cf Californium 1950 251 (251 - 251) Solid	99 Es Einsteinium 1952 252 (252 - 252) Solid	100 Fm Fermium 1953 257 (257 - 257) Solid	101 Md Mendelevium 1955 258 (258 - 258) Solid	102 No Nobelium 1967 259 (259 - 259) Solid

© Lanthanide Series

● Actinide Series



Name: _____

Dry Ice and Water

1. Predict what will happen when a chunk of dry ice is placed in the beaker of hot water.

2. Describe what happens when you put the chunk of dry ice in the beaker of hot water.

3. Explain what is causing the water to bubble.

4. Why was the bubbling rapid at first? Why does it begin to slow?

5. The dry ice in water “pops” every once in a while. Explain what is happening.

6. Does the dry ice disappear more quickly in air or in water? Explain your answer.

Name: _____

Dry Ice and Soap

1. Predict what will happen when dry ice is placed in the beaker of soapy water

2. Describe what happens when you put the chunk of dry ice in the beaker of soapy water.

3. What causes the physical reaction?

4. Why does the bubble tube move in downward?

Name: _____

Dry Ice and Isopropyl Alcohol

1. Predict what will happen when a dry ice is placed in the test tube.

2. Describe what happens when you put the dry ice in the test tube.

3. What causes the physical reaction?

4. What would you change to increase the reaction?

Dry Ice and Water Answer Key

1. Predict what will happen when a chunk of dry ice is placed in the beaker of hot water.
Predictions will vary.
2. Describe what happens when you put the dry ice in the beaker of hot water.
Bubbles start to emerge from the dry ice and rise through the water. On top of the water, a “fog-like” gas (CO₂) emerges and sinks down over the beaker.
3. Explain what is causing the water to bubble.
The dry ice is changing from a solid to a gas. The gas forms bubbles that rise through the water.
4. Why was the bubbling rapid at first? Why did it begin to slow?
At first, the warm water caused the dry ice to sublime rapidly. The water cools down as the heat/energy is used to change the state of the dry ice. As the water becomes cooler, it doesn't supply as much heat/energy to the dry ice so it sublimates at a slower rate.
5. The dry ice in water “pops” every once in a while. Explain what is happening.
The dry ice sublimates in every direction, even where it touches the bottom of the beaker. When a big enough bubble forms under the dry ice, it makes a “pop” as it releases and moves to the surface.
6. Does the dry ice disappear more quickly in air or in water? Explain your answer.
Dry ice disappears more quickly in water than in air because the transfer of heat is greater in the water. It is the heat that causes the sublimation to occur.

Dry Ice and Soap Answer Key

1. Predict what will happen when dry ice is placed in the beaker of soapy water.
Predictions will vary.
2. Describe what happens when you put dry ice in the beaker of soapy water.
The dry ice forms sublimates under the water and forms bubbles on the surface of the water. These bubbles “grow” and follow the shape of the beaker making a “tube of bubbles” that spills out over the beaker.
3. What causes the physical reaction?
The dry ice is heated which adds energy causing the dry ice to change states from a solid to a gas. The CO₂ is trapped in the bubbles.

4. Why does the bubble tube move in downward?

The bubble tube moves in a downward direction because CO_2 is heavier than the O_2 in the air and because the bubbles are connected to each other making it heavier.

Dry Ice and Isopropyl Alcohol Answer Key

1. Predict what will happen when a chunk of dry ice is placed in the test tube.

Predictions will vary.

2. Observation: Describe what happens when you put the chunk of dry ice in the test tube.

The dry ice sublimates from the energy/heat and changes to a gas. The pressure of the gas is so great that it pops the top off the container.

3. What causes the physical reaction?

The temperature of the isopropyl alcohol provides an energy/heat source which causes the dry ice to change states from a solid to a gas.

4. What would you change to increase the reaction?

Heat the isopropyl alcohol.