

Structure of Matter

Overview

Matter is everywhere, and its unique properties help us understand how substances behave and interact. In this lesson, you'll explore how matter changes between solid, liquid, and gas states and observe how different substances respond to changes in temperature and environment. Let's investigate the amazing properties of matter and uncover what makes each material special!

Background

Matter exists in three primary states: solid, liquid, and gas. Each state is determined by the arrangement and movement of particles. Solids have particles packed closely together, giving them a fixed shape. Liquids have particles that move freely, allowing them to take the shape of their container. Gases have particles that move rapidly and spread out to fill any space. Transitions between these states—melting, freezing, boiling, and evaporation—are called phase changes and involve energy transfer.

These phase changes, along with other characteristics, are examples of physical properties. Physical properties describe traits that can be observed or measured without changing the material into something new. Key physical properties include melting and boiling points, density, and temperature responses. For example, water boils at 100°C (212°F) at sea level, transforming into steam, while adding salt raises its boiling point. Observing these changes helps us understand how energy impacts a substance's behavior.

Chemical properties, in contrast, describe how substances transform into entirely new materials during reactions, such as rust forming on metal or wood burning to produce ash and gas. While this lesson focuses on physical changes, understanding the difference between physical and chemical properties is crucial for identifying and classifying materials.



Grades: Middle School

Time: 45 Minutes

Subject: Physical Science

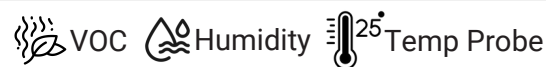
Topics: States of Matter, Phase Change, Humidity, VOC

What You Will Need/Prep

- databot with temperature probe
- IOS/Android Smart Device
- Small, sealed containers 
- Heat source
- Ice cubes, Rubbing alcohol, Water + Salt
- Safety equipment (goggles, gloves, etc.)
- Install Vizeey™ on your Smart device. 
- Scan the QR code to load the experiment.



- Test your databot™ connection.
- You will be prompted to select and connect to databot™ each time you launch an experiment.
- If there are two or more databot™'s listed, the one closest to your device will be highlighted.
- Study the background information and terms and prepare to explore!



In this hands-on lesson, you'll explore how substances like water, alcohol, and saltwater change their state when heated or cooled. By observing temperature and humidity changes, you'll uncover the unique properties of each substance and learn how these properties help distinguish one substance from another.

Learning Objectives

In this investigation you will master the following knowledge and skills:

- Use databot's sensors to collect, measure, and record temperature and humidity data accurately.
- Explore and identify the physical properties of water by observing its phase changes.
- Understand how temperature and humidity data reveal the processes of melting, boiling, and evaporation.
- Compare the boiling points of different substances and analyze the effects of solutes like salt on these properties.
- Interpret experimental data to draw conclusions about the physical properties of water, alcohol, and saltwater.

Important Terms

Matter: Anything that has mass and takes up space. It exists in different **states of matter**, such as solid, liquid, and gas.

Physical Properties: Characteristics of a substance that can be observed or measured without changing its chemical composition (e.g., melting point, boiling point, density).

Chemical Properties: Characteristics that describe a material's ability to undergo a chemical change, resulting in the formation of new substances.

Melting Point: The temperature at which a solid changes into a liquid.

Boiling Point: The temperature at which a liquid changes into a gas.

Evaporation: The process by which a liquid turns into a gas at a temperature below its boiling point.

Condensation: The process by which a gas turns into a liquid.

Humidity: The amount of water vapor present in the air.

Phase Change: A transition of matter from one state to another (e.g., solid to liquid, liquid to gas).

Solute: A substance dissolved in another substance, such as salt in water.

Volatile Organic Substance (VOC): A material that easily evaporates at normal temperatures due to its low boiling point. The concentration of VOCs is measured in ppb.

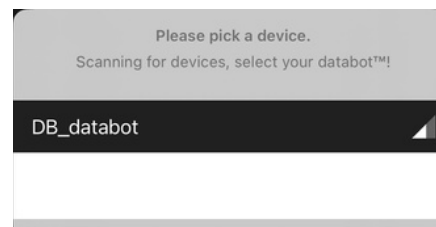
Parts Per Billion (PPB): Usually describes the concentration of something in air, water or soil.

Using Vizeey

In order to work with the experiment you need to launch the Vizeey application and click on + in the upper right corner.

Then select "Add experiment from QR code" and scan the QR code prepared for this experiment. Your experiment will appear in the list.

When you start the experiment you will be immediately offered to connect to your databot. Make sure that databot is enabled.

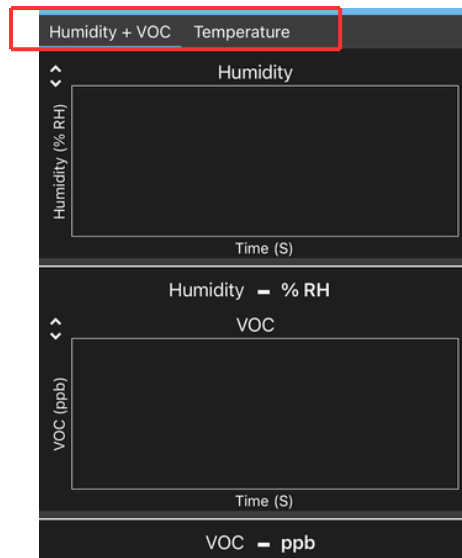


Once in the Experiment

This lab consists of 2 experiments. There is a separate tab for each experiment.

Click the "Fix Temp Value" button to Freeze the Boiling Point

Once you have Freeze the values, write them down in the table



The Databot has two operating modes:

- **Vizeey Mode** (for use with the Vizeey app).
- **Web Server Mode**

To activate Vizeey Mode:

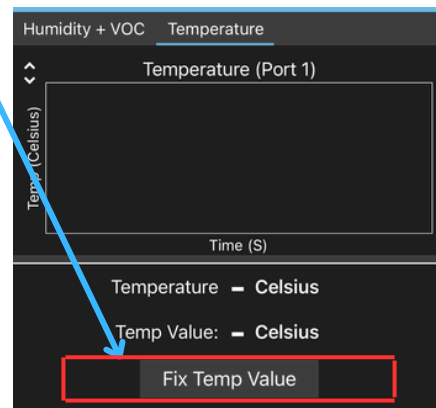
- Position the Databot with its sensors facing upward and turn it on.
- If the Databot's LED glows green, it's in Web Server Mode. If this happens, turn it off, adjust the orientation, and try again.



Good



Bad



Part 1: Initial Observations and Questions

Can you identify water from salt water or rubbing alcohol?

How does adding salt to water affect its boiling point?

What physical changes occur when ice melts into water?

Why does rubbing alcohol evaporate faster than water?

Part 2: Hypothesis

How do you think the humidity level in the container will change as the ice starts to melt? Why might humidity increase or decrease during melting and evaporation?

What differences do you expect between water and alcohol in terms of their physical properties? At what temperature do you think alcohol will boil compared to water?

Why is it important to make predictions before conducting an experiment? How can this help you in the scientific inquiry process?




Understanding Physical Properties of Water

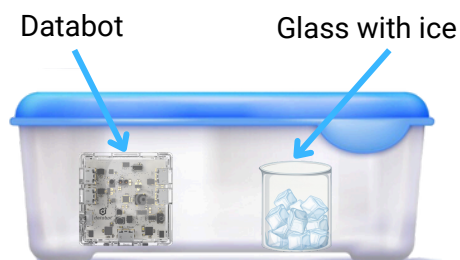
State	Description
Solid	Ice has a crystalline structure with molecules arranged in a tetrahedral formation due to hydrogen bonding. Ice is less dense than liquid water, allowing it to float.
Liquid	In this state, molecules are in close contact but can move freely, allowing water to take the shape of its container. The structure is less ordered than in ice but still retains some hydrogen bonding characteristics.
Gas	Water vapor consists of widely spaced molecules moving freely with high energy. The transition from liquid to gas occurs at boiling point (100°C) where all molecular bonds break completely.

Part 3: Experiment Procedure

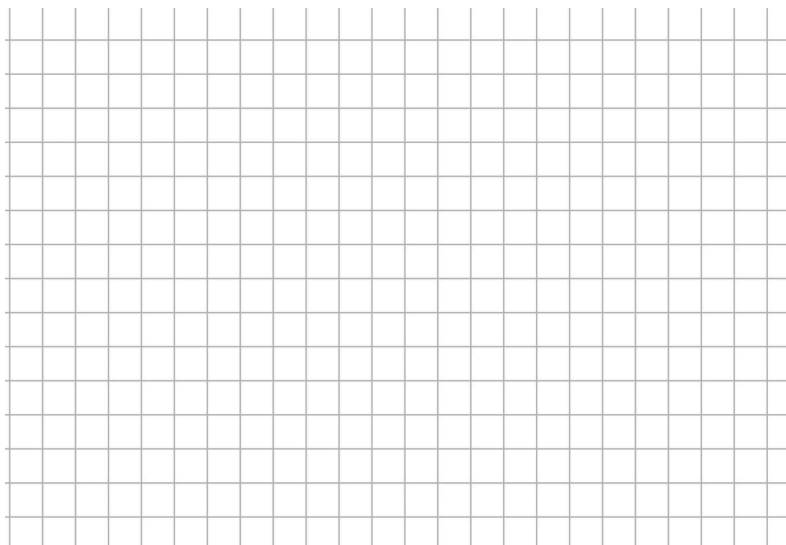
The experiment will be conducted in several parts, each aimed at studying the physical changes of water and other liquids.

Observing Ice

- Prepare a sealed container for the experiment.
- Place databot inside the container.
- Tap on "**Structure of Matter**" in Vizeey to load the experiment.
- You will be prompted to connect to databot.
 - Hint- if there is more than one databot in use, the one closest to you will be in blue!
 - A solid blue light on databot means you are connected.
- Select the tab **Humidity + VOC** for this experiment.
- Start your experiment using: 
- Use these icons   at the top of the screen in Vizeey to start and to pause the experiment.
- Place a small cup with ice cube into the container.
- Close the container and begin observations.
- Monitor the humidity and VOC readings.
- Record the values every 30 seconds into a table.
- Create a graph with the received data






Time (s)	Humidity	VOC
0		
30		
60		
90		
120		
150		
180		
210		
240		

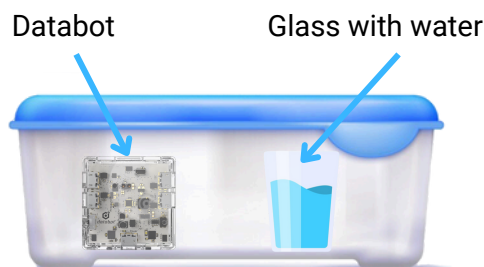


Before starting the next experiment, be sure to ventilate the container to allow humidity levels to equalize to room temperature.

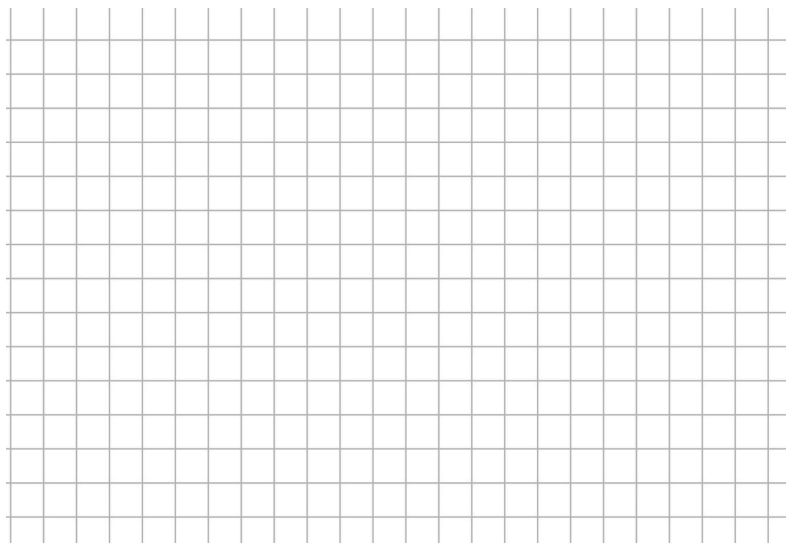
Part 3: Experiment Procedure

Observing Water

- Prepare a sealed container for the experiment.
- Place databot inside the container.
- Tap on **"Structure of Matter"** in Vizeey to load the experiment.
- You will be prompted to connect to databot.
 - Hint- if there is more than one databot in use, the one closest to you will be in blue!
 - A solid blue light on databot means you are connected.
- Select the tab **Humidity + VOC** for this experiment.
- Start your experiment using: 
- Use these icons   at the top of the screen in Vizeey to start and to pause the experiment.
- Place a cup of water into the container.
- Close the container and begin observations.
- Monitor the humidity and VOC readings.
- Record the values every 30 seconds into the table below.
- Create a graph with the received data






Time (s)	Humidity	VOC
0		
30		
60		
90		
120		
150		
180		
210		
240		

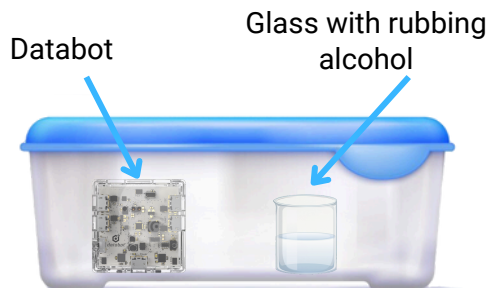


Before starting the next experiment, be sure to ventilate the container to allow humidity levels to equalize to room temperature.

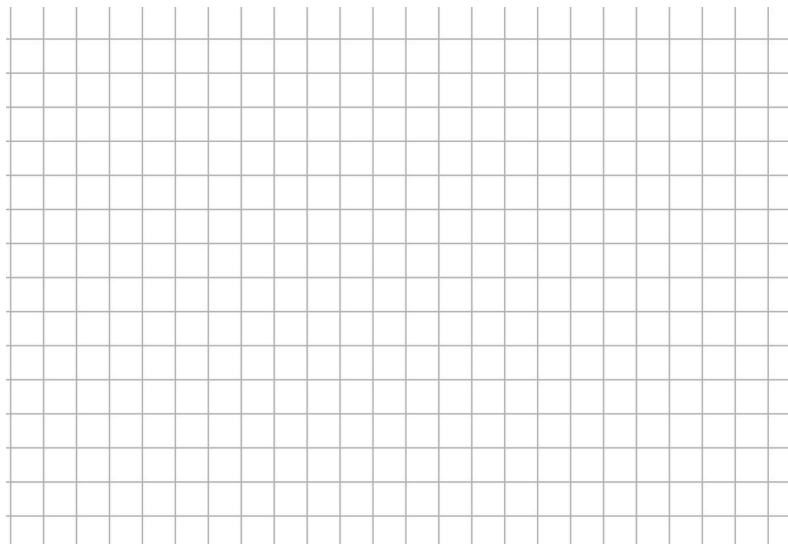
Part 3: Experiment Procedure

Observing Alcohol

- Prepare a sealed container for the experiment.
- Place databot inside the container.
- Tap on "**Structure of Matter**" in Vizeey to load the experiment.
- You will be prompted to connect to databot.
 - Hint- if there is more than one databot in use, the one closest to you will be in blue!
 - A solid blue light on databot means you are connected.
- Select the tab **Humidity + VOC** for this experiment.
- Start your experiment using: 
- Use these icons   at the top of the screen in Vizeey to start and to pause the experiment.
- Place a cup of rubbing alcohol into the container.
- Close the container and begin observations.
- Monitor the humidity and VOC readings.
- Record the values every 30 seconds into the table below.
- Create a graph with the received data.



Time (s)	Humidity	VOC
0		
30		
60		
90		
120		
150		
180		
210		
240		






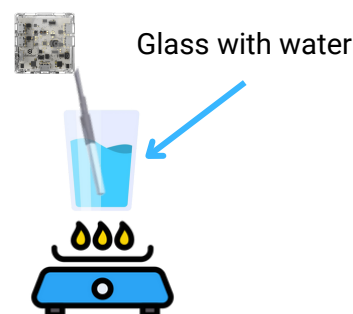
What amazing things did you discover in these three experiment?

Part 3: Experiment Procedure

We have observed the effect of different materials on humidity in the surrounding air. Now, let's conduct experiments to further explore the properties of liquids.

Boiling Point of Water

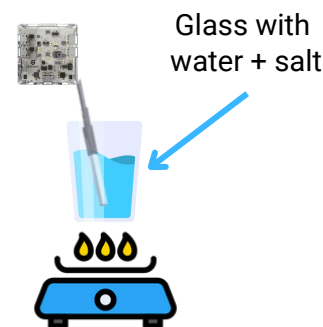
- Set up a heat source that allows you to boil water.
 - Remember to follow safety precautions while working with heat.
- Pour 100 ml of water into a glass.
- Turn on databot.
- Tap on "**Structure of Matter**" in Vizeey to load the experiment.
- You will be prompted to connect to databot.
 - Hint- if there is more than one databot in use, the one closest to you will be in blue!
 - A solid blue light on databot means you are connected.
- Select the tab **Temperature** for this experiment.
- Start your experiment using: 
- Use these icons   at the top of the screen in Vizeey to start and to pause the experiment.
- Plug the temperature probe into Port 1.
- Place the temperature probe into the container with water, ensuring that it is fully submerged in the water.
- Begin heating the water and monitor the temperature. Make sure that the temperature probe does not touch the walls of the beaker during measurements.
- As soon as the water reaches its boiling point, record the temperature.



What temperature does water boil? _____

Boiling Point of Salt water

- Add salt to the water based on a ratio of 6 g salt per 100 ml of water.
- Restart the Vizeey experiment. Repeat heating the solution of water with salt and observe the temperature changes.
- When the solution begins to boil, record the temperature.



What temperature does the solution of water with salt boil? _____

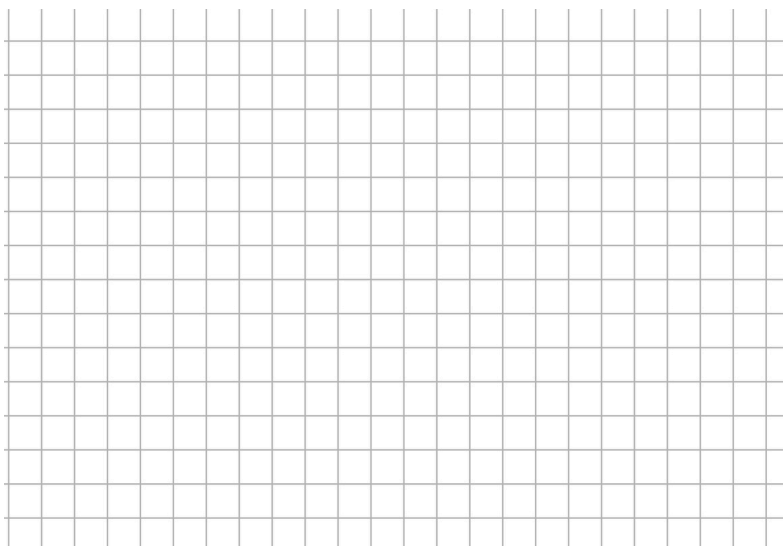
Part 3: Experiment Procedure

Boiling Point of Rubbing Alcohol

You will not boil rubbing alcohol in this lesson. The boiling point of 70% ethyl alcohol is about 78-80°C at normal atmospheric pressure. So, we can use this data for further analysis.

Part 4: Data Analysis

Make a histogram showing the temperature at which water, water + salt and rubbing alcohol boil.



Part 5: Concept Questions

Data Interpretation:

1. How does the addition of salt to water affect its boiling point?

2. At what temperature did the water start to boil? How close was this to 100°C?

3. Why during the evaporation of rubbing alcohol the humidity began to drop and the VOC began to rise.

Part 6: Reflection

1. How can you apply what you've learned about boiling points and humidity to real-world situations?

2. If you were to conduct a similar experiment with another liquid (e.g., oil or vinegar), what do you expect to find regarding its boiling point? What factors would you consider when designing that experim

3. How do you think changes in atmospheric pressure would affect the boiling points of water and other liquids?

4. What surprised you most about the results of your experiments?

5. What questions do you still have after completing these experiments?
