Lab Handout

Lab 3. Physical Properties of Matter

What Are the Identities of the Unknown Substances?

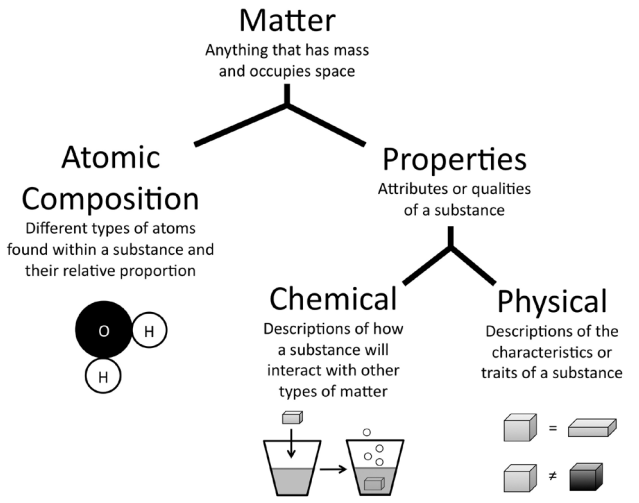
Introduction

Matter, the "stuff" of which the universe is composed, is all around us. Anything that we can touch, feel, or see is an example of matter. Matter can be defined as something that has mass and takes up space. All matter is composed of submicroscopic particles called atoms. A substance is a sample of matter that has a constant composition. Examples of substances include water, iron, plastic, and glass. On Earth, substances are found in one of three different states (i.e., solid, liquid, and gas), and it is common to see a substance change from one state to another. The types of atoms, the interactions that occur between atoms, and how the atoms are moving within a substance determine its state and its behavior under different conditions.

Scientists use atomic composition and specific chemical or physical properties to distinguish between different substances (see Figure L3.1). The atomic composition of a substance refers to the different types of atoms found in it and the relative proportion of each type of atom. Water, for example, is composed of hydrogen atoms and oxygen atoms in a ratio of two hydrogen atoms for every one oxygen atom. The chemical and physical properties of a substance refer to measurable or observable qualities or attributes that are used to distinguish between different substances. Chemical properties describe how a substance interacts with other matter. Sodium and potassium, for example, react with water, but aluminum and gold do not. Physical properties are descriptive characteristics of matter. Examples of physical properties include color, density, conductivity, and malleability. Every substance will have a unique set of chemical and physical properties that can be used to identify it, because every type of substance has a unique atomic composition.

FIGURE L3.1

How scientists distinguish between different substances



It is often challenging to determine the identity of an unknown substance based on its chemical and physical properties. A scientist, for example, may only have a small amount of a substance. As a result, the scientist may not be able to conduct all the different types of tests that he or she wants to because some tests may change the characteristics of the sample during the process (such as when a metal is mixed with an acid). It is also difficult to determine many of the physical properties of the sample, such as its density or its malleability, when there is only a small amount of the substance, because taking

measurements is harder. To complicate matters further, an unknown substance may have an irregular shape, which can make it difficult to accurately measure its volume. Without knowing the mass and the volume of a substance, it is impossible to calculate its density.

In this investigation, you will have an opportunity to learn about some of the challenges scientists face when they need to identify an unknown substance based on its physical properties and why it is important to make accurate measurements inside the laboratory.

Your Task

You will be given a set of known substances. You will then document, measure, or calculate at least three different physical properties for each substance. From there, you will return the known substances to your teacher, who will then give you a set of unknown substances. The unknown substances will consist of one or more of the known substances. Your goal is to use what you know about the physical properties of matter, proportional relationships, and patterns to design and carry out an investigation that will enable you to collect the data you need to determine the identity of the unknown substances.

The guiding question of this investigation is, **What are the identities of the unknown substances?**

Materials

You may use any of the following materials during your investigation:

Consumables

- Water (in squirt bottles)
- Set of known substances
- Set of unknown substances

Equipment

- Electronic or triple beam balance
- Beakers (various sizes)
- Graduated cylinders (various sizes)
- Pipettes
- Metric ruler
- Wire
- Size D battery
- Mini lightbulb
- Mini lightbulb holder
- Safety glasses or goggles
- Chemical-resistant apron
- Nonlatex gloves

Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

1. Wear sanitized indirectly vented chemical-splash goggles and chemical-resistant nonlatex gloves and aprons during lab setup, hands-on activity, and takedown.
2. Clean up any spilled liquid immediately to avoid a slip or fall hazard.
3. Handle all glassware with care.

4. Lightbulbs are made of glass. Be careful handling them. If they break, clean them up immediately and place in a broken glass box.
5. Handle electrical wires with caution. They have sharp ends, which can cut or puncture skin.
6. Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? ☐ Yes ☐ No

Getting Started

To answer the guiding question, you will need to make several systematic observations of the known and unknown substances. To accomplish this task, you must determine what type of data you need to collect, how you will collect it, and how you will analyze it.

To determine *what type of data you need to collect,* think about the following questions:

- Which three physical properties (e.g., color, density, conductivity, malleability, luster) will you focus on as you make your systematic observations?
- What information do you need to determine or calculate each of the physical properties?

To determine *how you will collect the data,* think about the following questions:

- What equipment will you need to collect the data you need?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect?
- How will you organize your data?

To determine *how you will analyze the data,* think about the following questions:

- What type of calculations will you need to make?
- What patterns do you need to look for in your data?
- What type of table or graph could you create to help make sense of your data?
- How will you determine if the physical properties of the various objects are the same or different?

Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

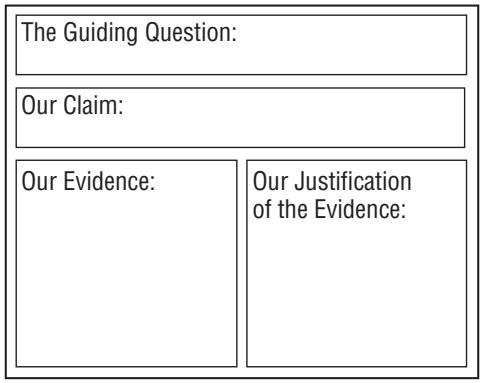
- how scientists use patterns as a basis for classification systems;
- how scientists need to be able to recognize proportional relationships between categories, groups, or quantities;
- the difference between data and evidence in science; and
- how scientists use different types of methods to answer different types of questions.

Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a *claim*, *evidence* to support your claim, and a *justification* of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally, the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L3.2.

FIGURE L3.2

Argument presentation on a whiteboard



Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- How did you collect your data? Why did you use that method? Why did you collect those data?

- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- How did your group analyze the data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?
- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most acceptable and valid answer to the research question!

Report

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer to the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable and valid!