

Physical Properties of Matter: What Are the Identities of the Unknown Substances?

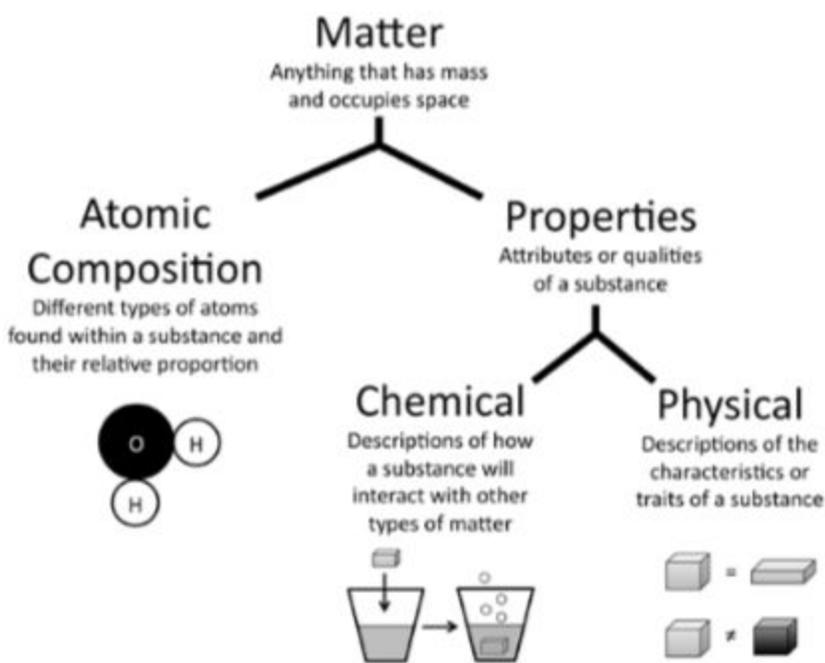
Introduction

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 below). 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

How scientists distinguish between different substances



physical properties that can be used to identify it, because every type of substance has a unique atomic composition.

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:

- Water
- Set of known substances
- Set of unknown substances
- Electronic or triple beam balance
- Beakers (various sizes)
- Graduated cylinders (various sizes)
- Pipettes
- Metric ruler
- Wire
- Size D battery
- Mini lightbulb
- Mini lightbulb holder

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?

Report

Once you have completed your research, you will need to prepare an investigation report that consists of four sections (be sure to have section headings):

1. Introduction: Give some background information on the topic. Explain what question were you trying to answer and include a hypothesis. (Background info, research question and hypothesis)
2. Procedure: What did you do during your investigation and why did you conduct your investigation in this way? (How you collected and analyzed data)
3. Data: Include a data table and/or graph to show your results. Be sure to include a title for your table or graph with labels for the variables.
4. Conclusion: What is your argument? (Claim - Evidence - Reasoning)

Your report should answer these questions in two pages or less. The report must be typed, and any diagrams, figures, or tables should be embedded into the document. Type your report on Google Docs (12 point font, double-spaced) and share it with your teacher. Your report will be graded based on the rubric in the class syllabus.