Properties of Pure Substances

A formative assessment task from
*Formative Assessment Activities for Middle School Physical Science*

The purpose of this activity is to reinforce students’ ability to use physical and chemical properties to identify substances and to examine and interpret evidence indicating that new substances with different properties are formed during chemical reactions.
Chemical Reactions
Properties of Pure Substances

Purpose
The purpose of this station is to reinforce students' ability to use physical and chemical properties to identify substances and to examine and interpret evidence indicating that new substances with different properties are formed during chemical reactions.

Essential Understandings
- Matter has physical and chemical properties and can undergo physical and chemical changes.
- Evidence indicates that new substances with different properties are formed during chemical reactions.

Materials
- Metric balance
- Metric ruler
- Graduated cylinder
- Water
- Aluminum and copper cubes of identical volumes (painted same color)
- Aluminum cylinder (also painted)
- Calculator

The following materials are included in the blackline masters for this station.

Station Information Sheet (1 per station)
Physical and Chemical Properties Cards (1 set per station)

Advance Preparation
1. Print one copy of all the blackline masters for this station using a color printer. Color is essential to the station activities. Make one copy of the Student Pages (including the glossary) for each student.

2. Laminate the Station Information Sheet.

3. Label the lighter cube A and the heavier cube B. Cubes and cylinder may be painted with metal spray paint.

4. Print, cut, and laminate the Physical and Chemical Properties Cards.
Station Setup

1. Tape the Station Information Sheet to the station table. Students will use this to confirm the station is set up correctly.

2. Place the two cubes of different masses, the cylinder, water, metric balance, metric ruler, and a set of Physical and Chemical Properties Cards at the station.

Procedures

1. Tell students to check the station setup against the Station Information Sheet when they arrive at the table. If anything is missing or out of place, they should notify you.

2. Pass out a copy of the Student Pages to each student. Instruct students to work through the procedures and answer the questions with their teammates.

3. As students work through the station activity, circulate around the room, checking their work and responding to questions.

Guide to Student Responses

Note—The suggested student responses presented below in italics represent the best possible answers to the student questions; actual student responses may vary.

Essential Question

What properties could be used to find out if a certain liquid was water?

Water has no odor, no color, boils at 100° C, freezes at 0° C, solid form floats on the liquid form, easily dissolves many substances, has a density of 1 g/cm³.

Procedure

1. Look at the Physical and Chemical Properties Cards. Use the table below to place the card letter in the row and column that best identifies the property on the card.

<table>
<thead>
<tr>
<th>Property</th>
<th>Physical Property</th>
<th>Chemical Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>flammability</td>
<td></td>
<td>F</td>
</tr>
<tr>
<td>hardness</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>solubility</td>
<td></td>
<td>D</td>
</tr>
</tbody>
</table>
2. Examine the two cubes at this station.
   a. Use the metric balance to determine the mass of each of the cubes. Record this data in the table that follows.
   b. Find the volume of the cubes using the formula $v = l \times w \times h$. Record this data in the table that follows.
   c. Calculate the density using the formula $d = m/v$. Record this data in the table that follows.

<table>
<thead>
<tr>
<th>Property</th>
<th>Physical Property</th>
<th>Chemical Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>color</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>ability to oxidize</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>melting point</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>state</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>boiling point</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>reactivity</td>
<td></td>
<td>H</td>
</tr>
<tr>
<td>conductivity</td>
<td>J</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass (g)</th>
<th>Volume (cm$^3$)</th>
<th>Density (g/cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cube A</td>
<td>Answers vary based on the size of the cubes</td>
<td>Answers vary based on the size of the cubes</td>
</tr>
<tr>
<td>Cube B</td>
<td>Answers vary based on the size of the cubes</td>
<td>Answers vary based on the size of the cubes</td>
</tr>
</tbody>
</table>
d. Using the Density Chart below, identify cube A and cube B. What is your rational for these identifications?

**Density Chart**

<table>
<thead>
<tr>
<th>Substance</th>
<th>Density</th>
<th>Substance</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>1.0</td>
<td>copper</td>
<td>9.0</td>
</tr>
<tr>
<td>aluminum</td>
<td>2.7</td>
<td>lead</td>
<td>11.4</td>
</tr>
<tr>
<td>zinc</td>
<td>7.1</td>
<td>gold</td>
<td>19.3</td>
</tr>
</tbody>
</table>

*Cube A is aluminum and cube B is copper. According to the chart of approximate densities, the density of aluminum is 2.7 g/cm³ and copper is 9.0 g/cm³. So cube A must be aluminum and cube B must be copper.*

3. Examine the unknown cylinder.

   ![Unknown cylinder]

   a. Determine the mass using the balance. Record this data in the table that follows.

   b. Determine the volume with the liquid displacement method using the graduated cylinder. Record this data in the table that follows.

   c. Calculate the density using the formula \( d = \frac{m}{v} \). Record this data in the table that follows.

<table>
<thead>
<tr>
<th>Unknown</th>
<th>Mass (g)</th>
<th>Volume (cm³)</th>
<th>Density (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>cylinder</td>
<td><em>answers vary based on size of cylinder</em></td>
<td><em>answers vary based on size of cylinder</em></td>
<td>2.7 g/cm³</td>
</tr>
</tbody>
</table>

   d. Identify the substance based on your knowledge of density as a characteristic physical property and the Density Chart. Describe in detail your procedure and show all mathematical calculations.

   *The unknown cylinder is made of aluminum. Find the volume using the liquid displacement method. Find the mass on the balance. Calculate the density using the formula \( d = \frac{m}{v} \). Compare the density to the Density Chart and find that it is most similar to aluminum at 2.7 g/cm³.*
4. When a copper penny reacts with some chemicals (step 1) and is later heated (step 2), it turns a golden color (step 3).

The density of the shiny gold-colored penny is 7.3 g/cm³. Has it actually become gold? Explain your answer using data from the Density Chart.

*The penny has not become gold. This is because the density of gold is 19.3 g/cm³, which is much higher than 7.3 g/cm³. Since density is a physical property of a pure substance, it cannot be gold.*

5. Butyric acid smells like really bad cheese.

When ethanol and butyric acid are combined it has a pleasing scent of pineapples!

*Has a physical reaction or a chemical reaction occurred? Explain your reasoning.*

*The presence of an odor change is a clue that a chemical reaction has occurred. This means that there is at least one new physical property in the products.*
6. Now that you have completed these exercises, return to the Essential Question. Would you like to modify or change your answer? Write any modifications to your answer below.

*Answers will vary.*
Physical and Chemical Properties Cards

A

Diamonds are harder than glass.

B

Ice melts at 0°C.

C

Iron rusts when exposed to water.

D

Salt dissolves in water.

E

Gold has a yellow color.

F

Sugar turns into carmel when heated.
Chemical Reactions: Properties of Pure Substances

G
Sugar is a solid at room temperature.

H
Sodium reacts vigorously when placed in water.

I
Water changes from a liquid state to a gas at 100°C.

J
Metals such as copper and aluminum can be used in electrical wiring.
Station Information Sheet
for Chemical Reactions: Properties of Pure Substances

Triple Beam Balance

Density Cubes

Unknown metal cube

Graduated Cylinder

Calculator

Metric ruler
Chemical Reactions
Properties of Pure Substances

Student Pages

Purpose

The purpose of this station is to reinforce your ability to:

• use physical and chemical properties to identify substances, and

• examine and interpret evidence indicating that new substances with different properties are formed during chemical reactions.

Before You Begin . . .

Check to see that all the items are present and organized according to the Station Information Sheet. If you notice a problem, notify your teacher immediately.

Materials

Physical and Chemical Properties Cards
Metric balance
Metric ruler
Graduated cylinder
Water
Two cubes of identical volumes and color
Metal cylinder
Calculator

Essential Question

What properties could be used to find out if a certain liquid was water?
**Procedure**

1. Look at the Physical and Chemical Properties Cards. Use the table below to place the card letter in the row and column that best identifies the property on the card.

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   a. Use the metric balance to determine the mass of each of the cubes. Record this data in the table that follows.

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   c. Calculate the density using the formula \( d = \frac{m}{v} \). Record this data in the table that follows.

   ![Cubes A and B]

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</table>

d. Using the Density Chart below, identify cube A and cube B. What is your rational for these identifications?

### Density Chart

<table>
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<tr>
<th>Approximate Densities of Substances (g/cm(^3))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substance</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>water</td>
</tr>
<tr>
<td>aluminum</td>
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<td>zinc</td>
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4. When a copper penny reacts with some chemicals (step 1) and later heated (step 2) it turns a golden color (step 3).

The density of the shiny gold-colored penny is 7.3 g/cm$^3$. Has it actually become gold? Explain your answer using data from the density chart above.

5. Butyric acid smells like really bad cheese.

When ethanol and butyric acid are combined it has a pleasing scent of pineapples!
Has a physical reaction or a chemical reaction occurred? Explain your reasoning.

6. Now that you have completed these exercises, return to the Essential Question. Would you like to modify or change your answer? Write any modifications to your answer below.

NOTE: Because other students are going to do the activity after you, be sure to put all the materials at the station back as you found them. Sometimes there will be materials that need to be renewed or replaced. If you need assistance or have any questions, ask your teacher.
I Need to Remember . . .

Complete this part **after** class discussion of this station.

I need to remember . . .
Glossary for Chemical Reactions: Properties of Pure Substances

**Boiling point**
Boiling point is the pressure at which the vapor pressure of a liquid is equal to the atmospheric pressure and liquid converts to a gas.

**Chemical property**
A chemical property is a characteristic that enables matter to undergo a change to its chemical composition.

**Chemical reaction**
A chemical reaction takes place when two or more substances interact to form a new substance or substances with different chemical properties. The organization of the original substances’ atoms is altered.

**Conductivity**
Conductivity is the ability of a substance to transmit heat, electricity, or sound.

**Density**
Density is the amount of mass per unit of volume in a substance.

**Flammability**
A substance that is flammable is easily set on fire.

**Hardness**
Hardness is the ability of a substance to scratch or be scratched by another substance.

**Mass**
Mass is the amount of matter in a substance and is usually measured in grams or kilograms.

**Melting point**
Melting point is the temperature at which a solid becomes a liquid.
**Oxidation**

Oxidation occurs when oxygen reacts with some other substance.

**Solubility**

Solubility refers to a substance that has the ability to be dissolved.

**Volume**

The volume of a substance measures the amount of space it occupies.