Topic 2.3
What are pure substances and how are they classified?

Overview

In this topic, students will discover that matter is classified into various categories: mixtures, pure substances, elements, compounds, metals, and non-metals. Students will practise research techniques and design an inquiry that examines the properties of metals and non-metals.

Common Misconceptions

- **Students may be confused by the difference between a molecule and a compound.** Students are introduced to molecules in Topic 2.5. To avoid confusion, simply refer to molecules as joined particles for now. All students need to grasp in this topic is that if the substance is made of joined particles it is a compound. Use the analogy of words. Simple words are like elements. Compound words are like compounds—they are made of two or more parts that work together to make sense as one word. A collection of different words (simple and/or compound) is like a mixture. Write examples on the chalkboard to help English language learners understand the analogy.
- **Students might find it difficult to identify some elements as metals because their metallic characteristics are not obvious.** For example, calcium is a metal but does not appear to be malleable or ductile at room temperature. Other metals such as copper are not shiny in oxidized form. Explain to students that they may need to examine all properties of an element to accurately identify it. Point out that one of the main differences between metals and non-metals is that metals are good conductors and non-metals are poor conductors. A conductivity test can confirm that calcium and copper are both metals.

Background Knowledge

Matter can be classified into pure substances and mixtures. Pure substances are made of one type of particle while mixtures are a combination of particles. Pure substances can be elements or compounds. Elements are made of one type of atom and compounds are made of elements that are chemically bonded. Because each particle of a compound is the same, the components of a compound are always in a set ratio. This is not true for mixtures. For example, air is a mixture that contains hydrogen and oxygen (and other gases) but the ratio of hydrogen to oxygen is not constant or predictable. In contrast, pure water is a compound that contains hydrogen atoms and oxygen atoms present in a 2:1 ratio. This is always true of pure water.

Elements can be further classified into metals and non-metals. Metals are found on the left hand side of the periodic table and non-metals are on the right. There are more metallic elements than non-metallic elements. All metals are conductive and shiny. Not all metals are malleable or ductile at room temperature. All metals are solid at room temperature except for mercury, which is a liquid.

Specific Expectations

- **C2.3** plan and conduct an investigation to compare and contrast characteristic physical properties of metals with those of non-metals
- **C2.5** investigate and compare the chemical properties of representative elements within groups in the periodic table families of elements
- **C3.2** describe the characteristics that distinguish elements from compounds

Skills

- understand and follow safe laboratory procedures
- select appropriate instruments and materials for inquiries
- select, organize, and record relevant information from various sources
- conduct inquiries, controlling some variables, to collect observations and data
- make and justify conclusions

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-40 summary of the materials required in this topic.

Literacy Strategies

Before Reading

- Have students preview the figures and captions and write down one thing each figure tells them and one question they have about it.
- Challenge students to find certain items in the spread as you call them out, for example, a diagram of a pure substance, or an equation for table salt.
- ELL The vocabulary, sentence structures, and text features may make the text difficult for English language learners to understand. Provide students with an outline that captures the most important ideas or create cloze passages, leaving out the key concepts. Go through this outline with them and then go to the text. Explain that in the text, the writer adds more information to help the reader understand. Point out some of those techniques: examples or things that are similar; the use of brackets to clarify or give more information; references to diagrams to help them see things visually; bold or italic text to point out that the information is important.

During Reading

- As students read, have them record the definition of each Key Term and list examples of that type of matter. Examples can be from the text and from students' own experiences. Guide English language learners' reading or have them read with a partner so that they can clarify and talk about the concepts as they work together.
- Model for students how to use the Learning Check questions to check their own understanding. Have students work in pairs to answer the Learning Check questions on page 115, and to look up any answers that they do not know.

After Reading

- Have students add the key terms to their pictorial glossaries. Each entry should have the word, a definition, and a picture. Have English language learners include an example and a non-example.
- Have students add metals and non metals, and examples, to the flow chart that they created in Learning Check question 2 on page 115.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Starting Point Activity, page 113	Students define "pure substances" and "mixture" and classify common household products as pure substances or mixtures, with justification.	• Supply students with **BLM 2-14 Topic 2.3 Starting Point Activity** or samples of products instead of having them brainstorm a list in step 3. • Have students who need help defining mixtures and pure substances on a chemical level complete the first half of **BLM 2-15 Classifying Matter**.
Learning Check, page 115	Students define "pure substances", give examples, and differentiate between an element and a compound.	• Have students who need help differentiating between elements and compounds complete the second half of **BLM 2-15 Classifying Matter.** • DI ELL Bodily-kinesthetic learners, spatial learners, English language learners, and students having difficulty with this concept will benefit from using a model kit to build examples of element particles and compound particles. Elements and compounds can also be created from paper clips for demonstration purposes. Use one type of paper clip for elements, and two different types or colours joined together for compounds. • ELL Ensure English language learners understand the questions (flow chart, bubble graphic).
Activity 2.6, page 116	Students research the properties and uses of an element and use this information to classify elements into groups.	• ELL Assign English language learners or struggling students simpler elements such as hydrogen, helium, or carbon, so they can concentrate more on the research process and less on understanding the information.
Investigation 2B, page 118	Students plan and perform an experiment to compare and contrast the physical properties of metals and non-metals.	• Provide hints to groups having difficulties. They should refer to their notes on the experiments they designed in Activity 2.4 and Investigation 2A. • DI Bodily-kinesthetic learners may need to touch and use the testing equipment before they consider how to use it in their procedure. • DI Encourage spatial learners to draw pictures of their procedures.

Topic 2.3 (Student textbook pages 112–119)

Using the Topic Opener

- Most of the chemicals in the world are found mixed with other chemicals. The analogy of a dip net separating fish from water is useful on a macro scale and prepares students to think on a smaller particle level about how mixtures can be separated physically by filtration.
- Explain to students that dip nets are an environmentally friendly fishing method. Fish are not harmed by the nets and can be released back into the water if they are not the right type or size.
- To further engage students, ask them why a crime lab would need a machine to separate the parts of a mixture. What sorts of chemicals would they be looking for? For example, a forensic scientist may need to separate the items vacuumed up at a crime scene to determine their origin or identity. For example, types of soil can indicate where a suspect has been and flecks of paint can be connected to a specific vehicle. Give English language learners an explanation of what is meant by a "forensic scientist" and a "crime lab".

Starting Point Activity (Student textbook page 113)

Pedagogical Purpose

This activity is designed to activate students' prior knowledge of the classification of matter. Students develop a method to use when classifying substances.

Planning	
Materials	Samples or photographs of mixtures and pure substances (optional) **BLM 2-14 Topic 2.3 Starting Point Activity** (optional) **BLM 2-16 Classifying Matter** (optional)
Time	15 min
Safety	Follow WHMIS warnings if using chemicals from storage.

Activity Notes and Troubleshooting

- Students should work in pairs to provide opportunities to discuss uses and composition.
- Some students may have trouble listing appropriate examples to classify. Supply these students with **BLM 2-14 Topic 2.3 Starting Point Activity**, which lists 10 common household items. Or provide concrete samples for students to classify.
- If using samples of chemicals, place them at stations around the room and have students rotate from chemical to chemical to reduce any potential safety issues.

Additional Support

- ELL English language learners may not have the vocabulary to name many of these products. They will benefit from having sample products in their packaging on hand. A brief discussion of what each product is and is used for will also help.
- Prior to doing this activity, have students complete the first half of **BLM 2-15 Classifying Matter.** They can work individually or in pairs. This will assist students in defining mixtures and pure substances.
- For a whole class activity, have student work in groups of four to complete a placemat activity. Display **BLM 2-15 Classifying Matter** and reveal the "Yes" and "No" examples one at a time. Students should list the characteristics common to the examples in the "Yes" column. Once you have shown all the examples, each group should discuss the properties they listed and decide on a common definition to write in the centre of the placemat.

- Students could also complete B**LM 2-15 Classifying Matter** individually and then share their answers in a class discussion.
- DI For spatial learners, use an interactive whiteboard to complete **BLM 2-15 Classifying Matter** or to illustrate the differences between particles in pure substances and mixtures.
- DI Bodily-kinesthetic learners will benefit from acting out the characteristics of a pure substance and a mixture. This is easily done if girls are considered to be one type of particle and boys another. A mixture of girls and boys would be standing randomly in the room. A pure substance could be just girls, just boys, or pairs of girls and boys, as long as individually there is only one type of "particle" or human grouping. Discuss how easy it would be to separate a mixture into its components compared to separating a pure substance into its components.

Answers

What Did You Find Out?

1. Classifications and comparisons will vary.
2. Students will find substances they have made or know the composition of easy to classify substances. Some substances, such as "pure" apple juice, might be more challenging.
3. Students will probably have made at least one modification. They may have forgotten to mention the number of types of particles or the ability to separate particles into their components.

Instructional Strategies

Pure substances are elements and compounds (Student textbook pages 114–115)

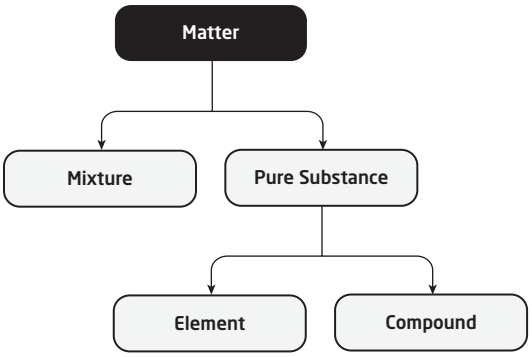
- After students read each key term, have them look at Figure 2.4. Ask them to explain why each chemical in the figure is a pure substance. Have them identify the compound (B) and elements (A and C) in the figure. Explain that the particles of water have two parts (the hydrogen part and the oxygen part).
- After reading, have students add the new words to their pictorial glossaries or to the word wall. Ask students to compare the terms "element" and "compound" using a Venn diagram, a cartoon, a poem, or a picture.
- Have students complete the second half of **BLM 2-15 Classifying Matter** to differentiate between elements and compounds. This can be done individually or as a placemat activity.
- DI For spatial learners, use an interactive whiteboard or the chalkboard to show the difference between the particles of an element and the particles of a compound.
- DI ELL Bodily-kinesthetic learners, spatial learners, English language learners, and students having difficulty with this concept will benefit from using a model kit to build examples of element particles and compound particles. Alternatively, invite students to develop analogies like the word analogy described in Common Misconceptions to help show the differences among elements, compounds, and mixtures.
- ELL Ensure English language learners understand the questions (flow chart, bubble graphic). You may need to clarify what is meant by desirable/undesirable, classification scheme, represented by, relate to, how, and then.
- Have students look at Figure 2.5 and discuss what each chemical must have in common to be a pure substance. Ask them to predict which chemicals are elements and which are compounds. On the chalkboard, draw simple diagrams of sodium, chlorine, and sodium chloride to show the particles in each substance.

- Ask students to explain the meanings of the plus sign and arrow sign in Figure 2.5 and then read the section above the figure. After reading, ask students to draw a picture to show the formation of water using hydrogen and oxygen.

Elements include metals and non-metals (Student textbook page 117)

- Before reading page 117, discuss the research students completed in Activity 2.6 and have students list the characteristics and common uses of metals. Ask students to explain why metals are used as cooking pots, electrical wiring, and jewellery.
- ELL Show English language learners Table 2.4 and describe how it is organized. Start with the two substances and review the terms, asking for an example and non-example of each. Name the properties and review what each is and ask for examples and non-examples. Working through one example will enable them to be successful during reading. Give them a sentence starter and complete it together "Conductivity is important because….".
- While reading, have students list the properties of metals, draw an example of the property in action, and write a sentence explaining why that property is important.
- Students might be surprised to learn that there are more metallic elements than non-metallic elements and that there is only one liquid metal (mercury).

Learning Check Answers (Student textbook page 115)

1. A pure substance is matter that contains only one type of particle. Gold and water are examples of pure substances.
2. 

3. *Similarities*: Both are pure substances and are made of one type of particle. *Differences*: Elements cannot be broken into simpler parts. Compounds can be broken into simpler parts by chemical methods.
4. Copper is an element. All samples of pure copper will contain the same type of particles no matter where they are found.

Activity 2.6 Classify Elements (Student textbook page 116)

Pedagogical Purpose

The purpose of this activity is to have students practise researching and organizing information and to reinforce the differences between metals and non-metals. The information that students gather in this activity will be used in later activities.

Planning	
Materials	Research material or Internet access Index cards
Time	45 min

Skills Focus

- select information from a variety of sources
- record data in an appropriate format
- organize data into categories

Activity Notes and Troubleshooting

- To avoid overlap of elements or the appearance of favouritism, put the names or pictures of the elements into a hat and have students draw the element they will research. This will add a bit of excitement to the process and keep it fair. If you want to assign simpler elements to struggling students, you can call them first and put the elements you want them to do on the top of the pile.
- See **www.scienceontario.ca** for on-line resources about the elements or have students find their own sources. Challenge students to show you why the websites they find are accurate and trustworthy.
- Have students copy the headings from the sample in the activity onto their index cards and fill in the information as they find it. They could give a description of their element's appearance instead of finding a photograph.
- Students are asked to make very brief notes about their element. Remind them that there are times to use full sentences and times to use a more concise point form, depending on their audience and the purpose of their writing.
- Collect students' index cards once they are finished the activity. You will need the cards for Activity 2.8.

Additional Support

- ELL You might want to assign English language learners or struggling students simpler elements such as hydrogen, helium, or carbon. This will allow them to concentrate more on the research process and less on understanding the information. Review the properties when looking at the example. Ensure students understand what is meant by "classify". Use simple everyday objects to demonstrate (pencils, pens, rulers, measuring tape, glue, staplers). Have students group the objects and explain why they are grouped or classified in this way.
- Enrichment—spatial or creative learners might enjoy making an advertisement for their element. Verbal and interpersonal learners might enjoy creating a fictitious dialogue or interview with their element.

Activity 2.6 Answers

What To Do

2. Groups might vary but the goal of this activity is to have students identify two distinct groups of elements: metals from non-metals. Students may not use these names, but they will explore the groups further on page 117 and in Investigation 2B.
Metals: lithium, beryllium, krypton, sodium, magnesium, aluminum, mercury, potassium, calcium, iron, gold, copper, nickel, uranium
Non-metals: hydrogen, helium, carbon, nitrogen, oxygen, fluorine, neon, sulfur, chlorine, argon

What Did You Find Out?

1. Answers may vary. Conductivity should be an important property discussed.

Learning Check Answers (Student textbook page 117)

1. All metals are shiny and solid (except for mercury). Metals can be different colours and some are more malleable than others. Non-metals can be solid, liquid, or gas and vary in colour and texture. All non-metals are dull and brittle.

2.

Metals	Non-metals
solid (except for mercury) shiny good conductors malleable ductile	solid, liquid, or gas dull poor conductors brittle not ductile

Investigation 2B Comparing the Physical Properties of Metals with Non-metals (Student textbook page 118)

Pedagogical Purpose

In this Investigation, student continue to develop their scientific inquiry skills by designing and performing experiments to compare the physical properties of metals and non-metals

Planning	
Materials	For each group: 10 cm copper wire or 2 copper pennies 4 cm square of aluminum foil 2 nickel ball bearings sulfur (the size of 25-cents) one small piece of carbon conductivity apparatus magnet magnifying lens hammer Other equipment or materials as required. **BLM 2-16 Investigation 2B** (optional)
Time	60 min
Safety	Wear gloves and aprons. Check that students do not have a sulfur allergy. Carbon dust is carcinogenic. Students should not hammer or crush carbon samples. Follow WHMIS warnings if using other elements.

Skills Focus

- work cooperatively
- follow laboratory safety procedures
- design a procedure
- record data in an appropriate format

Activity Notes and Troubleshooting

- Non-metals are very difficult to use in a secondary science classroom. Many of them are too toxic for students to work with safely given the equipment you have. If you would like students to test more elements, you could add more metals such as zinc, magnesium, and lead. However, these elements also have safety issues: zinc and magnesium are corrosive and lead is toxic.
- Carbon dust is carcinogenic. You might want to demonstrate the malleability of carbon under a fume hood while wearing a mask.
- Prepare kits for each group containing all the available materials (small lunch containers are great for this); place elements to be tested in labelled film canisters. You will need to order sulfur and carbon from a chemical supply store.

- If you do not have enough materials for each group, set up a station for each element and have groups rotate through the stations.
- If you do not have enough equipment for each group, set up a station for each type of equipment and have groups rotate through the stations with their elements.
- The challenge in this inquiry investigation will be for students to identify testable properties that apply to the materials you have prepared. This activity could be divided into two class periods: students design the procedure the first day then perform the experiments the second day.
- You could help students by listing the available equipment. If you think this will make the activity too simple, include extra equipment they might not need as a challenge.
- Provide hints to groups having difficulties. Ask them to list properties they might want to test. A list of properties can be found on page 117. Beside each property, have them explain how they would test that property and the materials they would need for the test. They should refer to their notes on the experiments they designed in Activity 2.4 and Investigation 2A.

Additional Support

- DI Bodily-kinesthetic learners may need to touch and use the testing equipment before they consider using it in their procedure.
- DI Encourage spatial learners to draw pictures of their procedures.
- ELL Explain the term "compare and contrast" with English language learners since it is a process that they will use often and in different subject areas.
- As an alternate investigation, provide students with five containers of mystery elements labelled A to E and challenge them to identify the metals and non-metals.

Investigation 2B Answers

What To Do

2. Procedures may vary. Students should get approval for their experiments before proceeding.

What Did You Find Out?

1.

	Metals	Non-metals
Properties shared by all samples	solid shiny good conductors	solid dull poor conductors brittle not ductile
Properties not shared by all samples	magnetic malleable ductile shiny (if samples have oxidized)	

2.

Metals	Non-metals
solid (except for mercury) shiny good conductors malleable ductile	solid, liquid, or gas dull poor conductors brittle not ductile

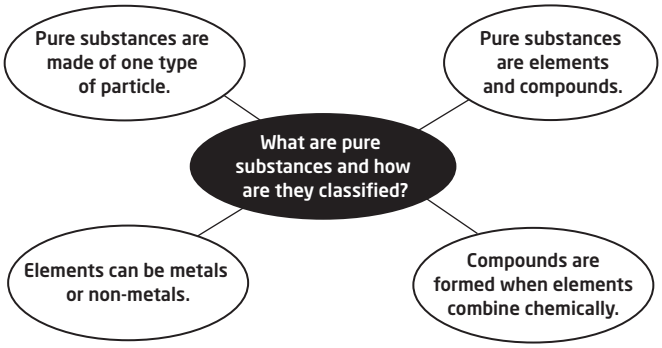
3. State, colour, and texture cannot be used to distinguish metals from non-metals.

Topic 2.3 Review (Student textbook page 119)

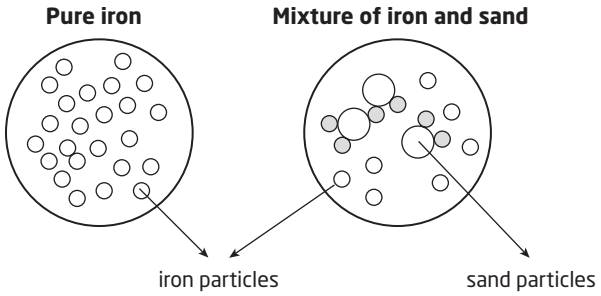
Please see also **BLM 2-17 Topic 2.3 Review (Alternative Format)**.

Answers

1.



2.



3. Aluminum is desirable for building aircraft because it is malleable. It is not desirable because it is a good conductor of electricity.

4. A mixture; B pure substance; C element (or compound); D compound (or element)

5. *Calcium carbonate*: Compound; more than one element in the name (calcium and carbon).
Table salt: Compound; made of sodium and chlorine.
Chlorine, neon, copper: Elements; listed in the periodic table.
Hydrogen peroxide: Compound; more than one element in the name (hydrogen and oxygen).

6. Metals are solid (except for mercury), malleable, ductile, shiny, and good conductors. An example could be copper, which can be flattened into sheets for roofing or pulled into wires for electrical wiring and jewellery.

7. Non-metals are brittle, dull, non-ductile, poor conductors, and can be solid, liquid, or gas. An example could be oxygen, which is a gas that we need for life.

8. Steel is a good metal for car doors because it is malleable but strong.

9. Steel is a mixture. It can be separated into its components by the physical method of applying heat.

10. An element that is a non-metal can be distinguished from an element that is a metal as follows:
Metals are solid at room temperature. So, all elements that are gases or liquids at room temperature (except for mercury) are non-metals. Solid elements that are brittle, dull, non-ductile, and poor conductors are non-metals. Solid elements that are malleable, shiny, ductile, and good conductors are metals.