

Science at Work



Carol Ann Budd is a professional engineer and research scientist.

Canadians in Science

Carol Ann Budd traces her interest in science to classroom experiments that she conducted as a student in Sudbury, Ontario. Fascinated by how chemicals and compounds reacted, she decided to study engineering chemistry at Queen's University in Kingston, Ontario. Today, she is a registered professional engineer and a research scientist in private industry. Of Anishinabe heritage, Carol Ann is also a director of CASTS, the Canadian Aboriginal Science and Technology Society. Here's what Carol Ann has to say about scientific research in Canada.

In Carol Ann Budd's Words

To continue its growth beyond its natural resources base, our country needs a lot of activity in research and development. I enjoy making a contribution by having a career focused on product research in plastics and polymers. Right now, I lead a team working to develop improved synthetic fibres to make better passenger air bags in automobiles.

Through CASTS programs, I use laboratory demonstrations to encourage students to take an interest in science and technology and to imagine where that interest might lead them. They could end up with jobs in pure science or in a related field, such as health, medicine, or business. In my work in product research, knowledge of chemistry and scientific principles is essential. Communication skills are also important. My co-workers and I need to communicate our findings clearly to persuade business leaders and investors to create new or better products based on our research.

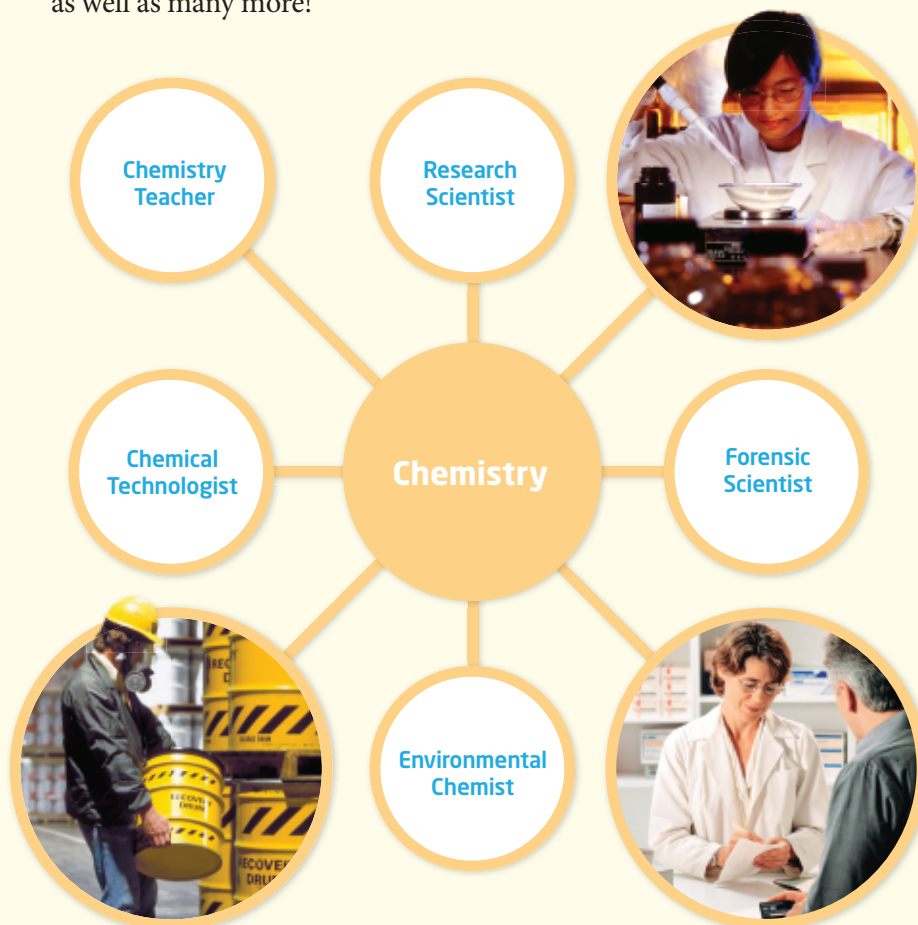
More than ever, we need to think about scientific research in a broad context because of social and environmental issues that challenge us. With their strong ties to the land, Aboriginal cultures remind us to respect Earth's resources and to consider potential future consequences of our actions. We need to ask, 'What effect will we have seven generations from now?' Increasingly, the scientific community needs to be sensitive to important environmental and social issues in order to help solve them.

To encourage student interest in science and technology, Carol Ann Budd organizes and conducts laboratory demonstrations in schools.



Chemistry at Work

The study of chemistry contributes to these careers, as well as many more!



Food Technologist

Food technologists use applied chemistry to develop new food products and ingredients. They prepare recipes and help to design the steps needed to produce new foods. They also help to ensure that packaging protects food and maintains its quality. An especially important part of food technology is testing products to ensure that they are safe for people to eat.

Pharmacist

Pharmacists dispense medication that medical doctors prescribe. In some provinces, regulations allow pharmacists to refill prescriptions without having to get a doctor's approval first. As well, pharmacists play an important role in health care by providing information about medication. They answer questions about medication and possible side effects, and they give advice on how to take medication correctly.

Occupational Safety Officer

Occupational safety officers monitor safety practices and train workers in how to handle chemicals properly. They also keep any legally required records about the storage and use of chemicals. If a hazardous spill occurs, occupational safety officers coordinate evacuation and clean-up efforts.

Go to [scienceontario](#) to find out more



Over To You

1. Provide some examples of research and development activities that you think are important to Canada. Explain why you think they are important.
2. In a small group, discuss whether research chemists have an obligation to ensure chemicals used to manufacture products are safely produced, used, and disposed of. Write a brief paragraph, summarizing your point of view.
3. From the list of careers in chemistry and related fields, choose one that interests you. Use library or Internet resources to research information about the career and what you would need to do to pursue it. **What essential skills would you need for this career?**



Unit 2 Projects

Inquiry Investigation

Rust Prevention

Because of its strength and availability, iron is one of the most widely used metals. But if you have ever left a bicycle outside in the rain, you know that iron rusts. Tendency to rust is a chemical property that causes the iron to become weaker as the reddish-brown rust flakes away. Rusting is a chemical change in which iron reacts with oxygen and water to form the compound iron oxide. Many millions of dollars are spent on technologies to slow or prevent the formation of rust.

Inquiry Question

Although iron rusts, other substances do not. How can you use the chemical properties of other materials to prevent iron from rusting?



Initiate and Plan

1. Suggest two different materials you could use to prevent iron from rusting. You might choose one of the following: plastic wrap, petroleum jelly, nail polish, or another material of your choice. Remember to set up your inquiry so that you test one variable at a time, comparing it to a control.
2. List the materials you will need, the steps in your procedure, and any safety precautions you should take.
3. Decide how you will rate the extent of rusting.
4. For each material you are testing (in other words, for each variable), write a hypothesis that
 - describes the results you expect to see; and
 - explains why you expect those results, based on the physical properties of the materials you are testing.
5. Have your teacher approve your investigation.

Perform and Record

6. Conduct your investigation. Record your results.

Analyze and Interpret

1. Compare the success of each material at preventing rusting.
2. What applications might there be for your discovery?
3. Identify any sources of uncertainty in your inquiry.

Communicate Your Findings

4. Present your results using both a visual and a written component.

Assessment Criteria

Once you complete your project, ask yourself these questions. Did you...

- **T/I** follow the procedure safely and record data accurately?
- **T/I** ensure that your evidence clearly refutes or supports the prediction for each variable tested?
- **T/I** identify sources of uncertainty?
- **A** make a connection between the science and practical application of the results?
- **C** communicate your results using appropriate language?

An Issue to Analyze

The Impact of Metal Mining

Ontario is the largest producer in Canada of nickel, gold, platinum, and cobalt. Ontario is also a significant producer of copper, zinc, and silver. In 2005, over \$4 billion worth of metal was produced in Ontario.

Issue

Do the benefits of metal mining justify the costs?

Initiate and Plan

1. Research on-line to find active metal mining operations in Ontario. Choose one operation (a single mine and metal) to analyze. Have your teacher approve your choice.
2. Before doing any further research, consider how the mining operation might both benefit and harm the local community, Ontario, and Canada.
3. Think of some questions to focus your research. To do this, consider the issue from different perspectives: social, technological, scientific, political, financial, and environmental. Consider researching some or all of the following questions:
 - Who is involved in this issue? (In other words, who are the stakeholders?)
 - How many jobs does the mine provide?
 - How do the metal's properties and its applications benefit society?
 - How does the mining operation affect the environment?
 - How do the products made from the metal affect the environment?
 - What does the mining company do to reduce its impact on the environment?
4. Decide how you will perform your research. What research sources will you use?

Perform and Record

5. Conduct your research to find answers to your questions.

Analyze and Interpret

1. On any issue there are differences of opinion. Based on your research, state your position on the issue and justify your position.
 - Should the mine be closed down? Why, and what proposals will you make to address the negative effects of its closing?
 - Should the mine remain open but with changes to how it operates? Why, and what changes would you suggest?
 - Should the mine continue to operate with no changes? How do you justify any negative effects the mine has?

Communicate Your Findings

2. Decide on a format in which to present your position and findings to your class, such as a newspaper article, a poster, or a podcast. If there is controversy about the project, you might act as moderator in a class debate.

Assessment Criteria

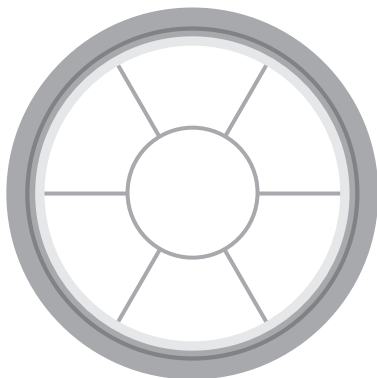
Once you complete your project, ask yourself these questions. Did you...

- **K/U** demonstrate knowledge of issues specific to metal mining?
- **T/I** formulate research questions effectively?
- **A** identify varying perspectives and stakeholders?
- **A** take a position, based on supporting evidence from several perspectives and propose an alternative solution if your position differs from what is currently being done?
- **A** provide a rationale if the position you take suggests no changes?
- **C** present your report clearly using appropriate language?

Unit 2 Review

Connect to the BIG IDEAS

Use this bicycle wheel graphic organizer to connect what you have learned in this unit to the Big Ideas, found on page 133. Draw one bicycle wheel for each Big Idea and write the Big Idea in the centre. Between the spokes of the wheel, briefly describe six examples of that Big Idea.



Knowledge and Understanding K/U

For questions 1 through 5, select the best answer.

- Which of the following is a chemical property?
 - density
 - reactivity with water
 - solubility
 - boiling point
- Who was the first scientist to discover that atoms are divisible?
 - Mendeleev
 - Rutherford
 - Thomson
 - Dalton
- A sodium atom is composed of 11 protons, 12 neutrons, and 11 electrons. Which of the following describes the particles that make up an ion of this isotope of sodium?
 - 11 protons, 12 neutrons, and 10 electrons
 - 10 protons, 12 neutrons, and 11 electrons
 - 11 protons, 11 neutrons, and 10 electrons
 - 11 protons, 13 neutrons, and 12 electrons
- In which family would you expect to find an element that is very reactive with water and whose atoms have one valence electron?
 - halogens
 - noble gases
 - alkaline-earth metals
 - alkali metals
- Which of the following is a molecular compound?
 - CCl_4
 - MgCl_2
 - KCl
 - NaI
- Describe each of the following physical properties of matter, and provide an example of each one.
 - boiling point
 - electrical conductivity
 - solubility
- A sample has a mass of 15 g and a volume of 6.0 cm^3 . Calculate the density of the sample.
- Iron has a density of 7.87 g/cm^3 . What is the mass of a 2.50 cm^3 piece of iron?
- A laboratory technician has measured the following data for two liquids that are insoluble in each other.

Liquid A: 5.0 mL has a mass of 6.8 g
Liquid B: 2.5 mL has a mass of 2.3 g

If these liquids are added to the same flask and allowed to separate into two layers, which liquid would be on top? Explain why.
- Identify two physical properties and one chemical property of water.
- What is the charge associated with each type of particle?
 - a proton
 - an electron
 - an ion formed by gaining an electron
- Describe the relative mass of a proton, a neutron, and an electron.

13. How does an atom's valence electrons influence the element's chemical properties?

14. Draw a Bohr-Rutherford model for each atom or ion.

- a. Na
- b. Ar
- c. C
- d. S^{2-}
- e. Mg^{2+}
- f. P^{3-}

15. Determine the number of protons, electrons, and neutrons in each atom.

- a. $^{13}_6C$
- b. $^{52}_{24}Cr$
- c. $^{32}_{16}S$
- d. $^{14}_7N$

16. Using standard atomic notation, provide an example of an isotope of each atom in question 15.

17. Distinguish among the terms *atomic number*, *atomic mass*, and *mass number*.

18. Explain how the size of the atoms changes as you move down a family in the periodic table.

Thinking and Investigation T/I

19. List the steps you would take to deal with each situation safely.

- a. While you are using a hot plate to heat a liquid, the fire alarm sounds.
- b. You are heating a test tube in the flame of a Bunsen burner when you notice that your test tube has a chip near the top.

20. Describe the laboratory tests that are used to identify each of the following gases.

- a. hydrogen
- b. oxygen
- c. carbon dioxide

21. Explain why sodium metal would not be a good material to use for a water bottle.

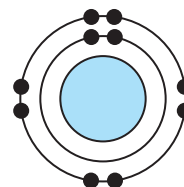
22. Use the information in the following table to answer the questions below.

Atomic Properties

Element	Number of Valence Electrons	Atomic Mass	Atomic Number
A	6	16.0	8
B	2	40.1	20
C	8	39.9	18

- a. Which element is located farthest to the left in the periodic table? Explain your reasoning.
- b. Which element is a noble gas? Explain your reasoning.
- c. Which element is most likely to form negative ions? Explain your reasoning.
- d. Which element appears latest in the periodic table? Explain your reasoning.
- e. Which element has the highest electrical conductivity? Explain your reasoning.

23. Use the following Bohr-Rutherford model to answer the questions below.



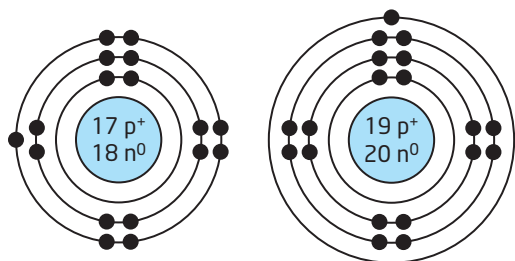
- a. If this model represents an atom, what element is it?
- b. If this model represents an ion with a charge of $3-$, what element is it?
- c. If this model represents an ion with a charge of $2+$, what element is it?

24. Compare elements and compounds. Clearly describe the relationship between them.

25. Make a table to compare ionic compounds and molecular compounds. Include their properties, as well as how their valence electrons are involved in bonding.

Unit 2 Review

26. Use the following Bohr-Rutherford models to answer the questions below.



- Do these models represent neutral atoms or ions? Explain.
- If these two elements combine, is the compound that forms ionic or molecular? Explain.
- Draw a Bohr-Rutherford model for the compound that forms if these two elements combine. Label the type of bond that forms.
- What is the name of the compound that forms?

Communication C

27. Organize the following models of the atom in the order they were developed. Write the names of the models, from earliest to latest, across the width of a page in your notebook. Under each name, draw a sketch of the model and briefly describe the experimental evidence that supported the model.

Thomson's model	Dalton's model	Bohr's model	Rutherford's model
-----------------	----------------	--------------	--------------------

28. Use library and/or Internet resources to research the different types of polyethylene. Create a table to summarize the properties and uses of each type.

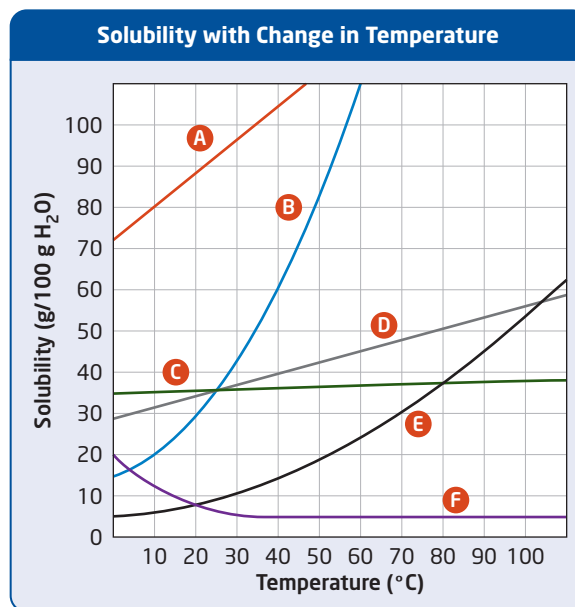
29. Sketch an outline of the periodic table, and identify the following on your outline.

- | | |
|----------------|--------------------------|
| a. metals | d. alkali metals |
| b. non-metals | e. alkaline-earth metals |
| c. noble gases | f. halogens |

Application A

30. The following graph shows the solubility of six compounds, represented by the letters A, B, C, D, E, and F.

Effect of Temperature on Solubility



- Which compound is the most soluble at 20°C?
 - Which compound's solubility is least affected by changes in temperature between 0°C and 30°C?
 - Which compound's solubility increases as the temperature decreases?
- How has the presence of mercury in waterways affected the environment and the lives of Aboriginal peoples in Canada?
 - Use the chart in **Figure 6.12** on page 230 and your knowledge of the properties of salt to develop a road-salt application strategy. Your strategy should focus on reducing the use of road salt and its effects on the environment.
 - A scientist wants to develop a new drug that interacts with a specific site on DNA. Describe how molecular models can help to accomplish this.

Literacy Test Prep

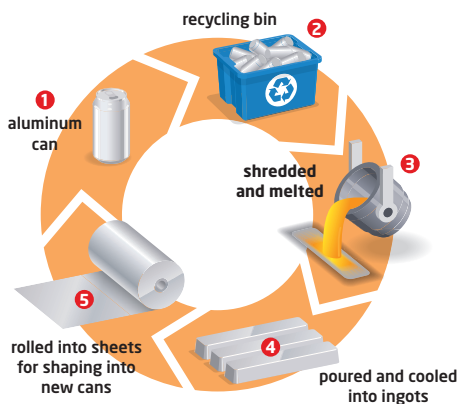
Read the selection below and answer the questions that follow it.

Aluminum Production

Aluminum is an extremely useful material because of its properties. Aluminum has a low density compared with other metals, so it forms very strong, lightweight alloys with other metals. It is very reactive but does not corrode. Aluminum is easy to work with, so it can be flattened and bent to the desired shape. It also has very good thermal and electrical conductivity.

Aluminum is obtained from a compound called aluminum oxide, which comes from bauxite that is mined. A large amount of electrical energy is needed to process the bauxite and aluminum oxide. Although bauxite is not mined in Canada and must be imported, our abundant hydroelectric power plants allow Canada to be one of the world's primary producers of aluminum.

Each year, approximately 1.5 billion kg of aluminum are used to produce beverage cans in North America. This requires about 5 billion kilowatt-hours of electricity—the same amount of electricity that is used by over half a million homes each year. Recycling the aluminum in cans, however, requires only 5 percent of the energy needed to make new aluminum. Also, unlike most other metals, 100 percent of the aluminum can be recycled.



Multiple Choice

In your notebook, record the best or most correct answer.

34. Canada is a large producer of aluminum because Canada has many
- bauxite mines
 - hydroelectric power stations
 - beverage canning factories
 - deposits of elemental aluminum

35. Aluminum is extremely useful because of all the following properties **except**
- its ability to form alloys
 - its high thermal conductivity
 - its ability to be easily shaped
 - its high density
36. What is the correct order in the production of aluminum beverage cans?
- bauxite → aluminum oxide → cans
 - aluminum oxide → bauxite → aluminum → cans
 - bauxite → aluminum → aluminum oxide → cans
 - bauxite → aluminum oxide → aluminum → cans
37. The purpose of the information in the last paragraph is to
- encourage the reader to recycle aluminum cans
 - organize information about the production of aluminum
 - inform the reader of worldwide aluminum use
 - recommend that the reader use less energy in the home
38. The purpose of the diagram is to show
- how many aluminum cans are recycled each year
 - how much energy is saved by recycling an aluminum can
 - how an aluminum can is recycled into aluminum foil
 - how an aluminum can is recycled into another can

Written Answer

39. Aluminum is used to manufacture parts for airplanes. Describe two properties of aluminum that you think are important in the production of these parts. Use specific details from the selection to support your answer.