Science at Work

Dalia Bagby is a forensic scientist at the Ontario Centre of Forensic Sciences.

Canadians in Science

When Dalia Bagby goes to work, she steps into a world where little things really do matter. Dalia is a scientist in the chemistry section of the Ontario Centre of Forensic Sciences (CFS). Police investigators routinely call on Dalia and her co-workers to examine materials—often only trace amounts of materials—collected at crime scenes. Dalia and her co-workers then prepare reports to detail their scientific findings. These reports can be entered as evidence during criminal court cases. Dalia has advanced degrees in chemistry from the University of Toronto and a keen interest in the justice system. She therefore considers the CFS to be the perfect work environment for her.

In Dalia Bagby's Words

It is rewarding to support investigative activities through impartial scientific analysis, although cases can be challenging at times. We often have little to work with. For example, a deliberately set fire may destroy much of the evidence that an ignitable liquid was used to fuel it. Glass fragments or paint chips from a hit-and-run accident may be the only clues about the type of vehicle involved.

Unlike what many popular television series portray about forensic science, my work almost always begins in the lab. My colleagues and I rarely visit crime scenes. Investigators bring materials to us. As scientists and technicians, we need solid analytical skills and thorough knowledge of laboratory procedures, especially procedures related to keeping custody of evidence.

As complex as my forensic science work can be, much of it is built on fundamental concepts that I learned in high school chemistry. My message to students who are interested in careers in science is to master the basics of core subjects. These basics include knowledge of the underlying principles of scientific inquiry and observation, as well as the nature of chemical reactions. This knowledge is even important for students who are not interested in careers in science. Chemistry is all around us. Something so fundamental to our world and everything in it should not be an enigma to anyone.

Dalia's work requires careful analysis of samples that are provided by police investigators.

Chemistry at Work

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

Occupational Health and Safety Officer

Occupational health and safety officers help prevent injury and disease in the workplace. They evaluate safety policies, provide training to employees and develop strategies to reduce health and safety risks. The officers need knowledge of chemistry to understand the chemical hazards in a workplace.

Chef

Chefs manage the preparation of food in restaurants, hotels, and other locations. They often create new recipes and must understand how different food ingredients will react with one another.

Patent Agent

Patent agents help inventors to obtain certain legal rights, including an exclusive right for 20 years to make, use, or sell their inventions. Patent agents often have education and training in chemistry and other sciences. This helps them to better understand complex inventions that might include, for example, new chemical compositions, prescription drugs, and methods to make them.

Go to **scienceontario** to find out more

Over to You

1. In a small group, discuss how scientific investigation in a forensic sciences laboratory may differ from that at colleges and universities or in private industry.
2. Dalia Bagby states that she and her co-workers must follow procedures related to maintaining custody of evidence. What do you think some of these procedures might be?
3. In Ontario, the Centre of Forensic Sciences does not routinely analyze samples related to pollution and other environmental offences. Research and report on how the province of Ontario usually deals with these matters.
4. Research a career involving chemistry that interests you. If you wish, you may choose a career from the list above. **What essential skills would you need for this career?**

Unit 2 Projects

Inquiry Project

"Mining" Copper in the Laboratory

Canada is one of the leading producers of copper in the world. Because copper is a good conductor of electricity and heat, it is often used to make wire. When the ore is mined, it is processed to extract metallic copper, which is the form that is used to make wire and other products. In this project, you will use your knowledge of chemical reactions to recover the maximum amount of metallic copper from a copper compound.

Inquiry Question

How can you extract metallic copper from copper(II) carbonate?

Initiate and Plan

1. Create a graphic organizer of your choice, using both words and visuals, to summarize the most important skills and concepts you learned in each investigation in this unit. Exchange summaries with a partner. In what ways are the summaries similar? What additional information might you add to your summary to make it more comprehensive?
2. Formulate a hypothesis, using a series of possible chemical reactions that show how the maximum amount of metallic copper might be extracted from copper(II) carbonate. For each reaction, include a one-sentence explanation and a chemical word equation.
3. Develop a procedure to extract copper from copper(II) carbonate. Identify appropriate equipment and quantities of materials required.
4. Obtain approval from your teacher before carrying out your procedure.

Perform and Record

5. Record your data using an appropriate format. Begin by recording the initial mass of copper(II) carbonate.
6. Carry out your procedure, controlling the appropriate variables, adapting or extending your procedure as required, and using the equipment and materials safely, accurately, and effectively.
7. Measure the mass of the metallic copper you extracted.

Analyze and Interpret

1. Determine the mass of copper that could theoretically be extracted from the mass of copper(II) carbonate you used. Assume that approximately half of the mass of copper(II) carbonate is carbonate, and half is copper.
2. Write a conclusion, based on the evidence you gathered, to support or refute your initial hypothesis.
3. Identify possible sources of error in your procedure, and suggest improvements.

Communicate Your Findings

4. Make a poster to illustrate the steps in your procedure. Your poster should include a word equation and a balanced chemical equation for each step; any mathematical calculations you made; the types of chemical reactions involved.

Assessment Criteria

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

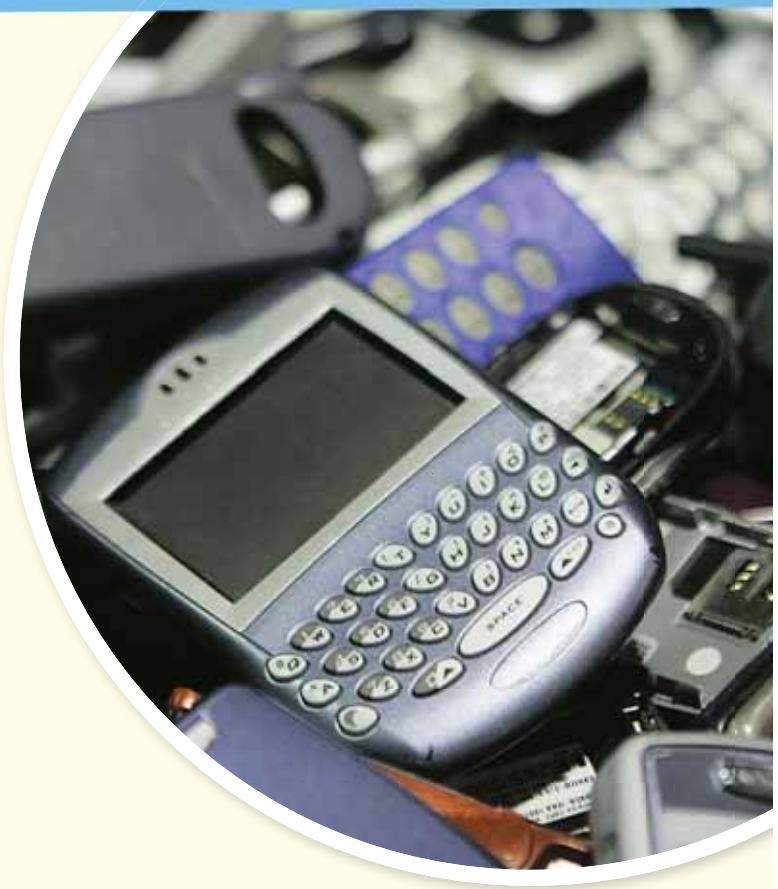
- K/U identify the important skills and concepts you learned in each investigation in this unit?
- T/I formulate an appropriate hypothesis?
- T/I control appropriate variables and use equipment and materials safely, accurately, and effectively?
- T/I determine the theoretical mass of copper that could be extracted from the mass of copper(II) sulfate you used?
- T/I identify sources of error and make suggestions for improvements?
- C organize your information in a clear and logical manner, appropriate for your purpose and audience?
- C communicate using appropriate scientific vocabulary?

An Issue to Analyze

Urban Gold "Mining"

Nuggets of pure gold are occasionally found in nature, as they were in Yukon streams during the Gold Rush of the 1890s. Most of the world's supply of gold has come from mines, but many mines have run out of gold and closed down. In the last 30 years, however, as personal electronic devices have become increasingly popular, there is a new source of gold–recycled gold from e-waste.

Televisions, computers, cellphones, and other electronic and communications devices all contain gold because it is an excellent conductor of electricity and does not corrode. From 1 tonne of discarded cellphones, it is possible to recover 150 g of gold. In comparison, an average gold mine yields only 5 g of gold from 1 tonne of ore. Although "mining" e-waste for gold seems promising, there are consequences. In this project, you will research various perspectives on this issue and, based on your research, provide a recommendation to the Ontario Mining Association.



Issue

Is it worthwhile to "mine" e-waste for gold?

Initiate and Plan

1. Conduct research to investigate the possibility of retrieving gold from e-waste. Consider the following perspectives as you conduct your research:
   - scientific
   - technological
   - environmental
   - societal

   Also consider the perspectives of the stakeholders involved. Gather information from print, electronic, and human sources.

Perform and Record

2. Record and organize the information you gathered using a graphic organizer of your choice and an accepted form of academic documentation.

Analyze and Interpret

1. Analyze your research for bias and accuracy.
2. State your position on the issue of retrieving gold from e-waste. Explain your position.
3. Propose alternative courses of action if you concluded that retrieving gold from e-waste should not occur.

Communicate Your Findings

4. Present your position on this issue, using a format that allows for discussion and feedback, such as a podcast or a presentation. Include the research you used to support your position. Use appropriate scientific vocabulary.

Assessment Criteria

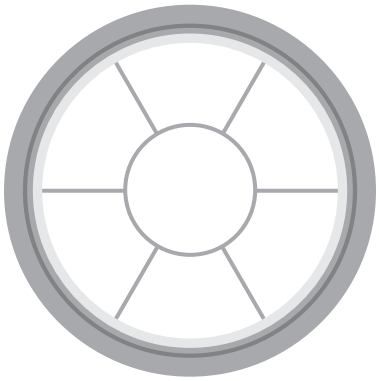
Once you complete your project, ask yourself these questions. Did you...

- K/U provide an accurate description of mining e-waste for gold?
- A clearly state your position on this issue, based on supporting evidence?
- A identify various perspectives and stakeholders?
- A propose alternative courses of action if you do not support mining e-waste for gold?
- C organize your research using an appropriate format and appropriate academic documentation?
- C present your final report using a format that is appropriate for both your purpose and audience?
- C communicate using appropriate scientific vocabulary?

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

1. A student observed each of the following when conducting a chemical reaction. Identify the observation that does *not* represent evidence of a chemical change.

a. The solution became hot.

b. The solid reactant dissolved in the solvent when added to the flask.

c. The solution became blue as the reaction proceeded.

d. Oxygen gas formed, and bubbles came out of solution.

2. Which of the following is the correct chemical formula for dinitrogen tetroxide?

a. NH_4O_6 **c.** N_2O_4

b. $2NO_2$ **d.** N_2O_3

3. Which of the following is the correct name for $Ti(SO_4)_2$?

a. titanium sulfite

b. titanium(IV) sulfate

c. titanium sulfate

d. titanium(III) sulfite

4. Which of the following chemical formulas represents a total of 12 atoms of oxygen?

a. $2Fe(NO_2)_3$ **c.** $3Sn(SO_4)_2$

b. $2Cr(NO_3)_3$ **d.** $4Cu_3(PO_4)_2$

5. When the following chemical equation is balanced, what is the value of x?

$xCr + yO_2 \rightarrow zCr_2O_3$

a. 1 **c.** 3

b. 2 **d.** 4

6. Explain why the law of conservation of mass is important for balancing chemical equations.

7. For each of the following, identify the type of reaction and balance the chemical equation.

a. $S_8(s) + O_2(g) \rightarrow SO_2(g)$

b. $HF(g) \rightarrow H_2(g) + F_2(g)$

c. $H_2SO_4(aq) + NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(\ell)$

d. $Fe(NO_3)_3(aq) + KOH(aq) \rightarrow Fe(OH)_3(s) + KNO_3(aq)$

e. $Al(s) + CuCl_2(aq) \rightarrow AlCl_3(aq) + Cu(s)$

8. Represent each of the following reactions using a word equation, a skeleton equation, and a balanced chemical equation. Include the states of the reactants and products.

a. Freshly cut sodium reacts with oxygen gas in the air and forms solid sodium oxide.

b. When a piece of magnesium ribbon is placed into a solution of copper(II) chloride, copper metal and a solution of magnesium chloride form.

c. Solid magnesium oxide and carbon dioxide gas form when powdered magnesium carbonate is heated.

d. When aqueous solutions of chromium(III) chloride and potassium hydroxide are mixed, a solution of potassium chloride and a precipitate of chromium(III) hydroxide form.

e. Bubbles of hydrogen gas form when a piece of aluminum metal is placed in a solution of sulfuric acid. The resulting solution contains aluminum sulfate.

9. Identify the type of reaction in each part of question 8. Explain your reasoning.

10. What approximate pH value would you expect for each of the following?

a. tomatoes

b. oven cleaner

c. milk

11. If the pH of a solution drops from 5 to 4, has the acidity increased or decreased? How much higher or lower has the concentration of hydrogen ions become?

12. What kind of substance is formed in addition to water, in an acid-base neutralization?

Thinking and Investigation T/I

13. When copper is heated in air, the solid product that is formed has a greater mass than the original copper. When calcium carbonate is heated in air, the solid product that is formed has less mass than the original calcium carbonate. Why is the mass of the solid product greater in one reaction but less in the other reaction?

14. Carbon monoxide, a poisonous gas, reacts slowly with oxygen to form carbon dioxide.

a. Represent the chemical reaction described using a balanced chemical equation.

b. In the presence of rhodium metal (Rh), this reaction occurs very quickly. What do you think the metal is doing?

Use the table below to answer questions 15 and 16.

pH Indicators

Indicator	Colour at Lower pH Values	pH Range in Which Colour Changes	Colour at Higher pH Values
Methyl orange	red	3.2–4.4	yellow
Methyl red	red	4.8–6.0	yellow
Phenolphthalein	colourless	8.2–10.0	pink

15. A solution causes methyl orange to be yellow and methyl red to be red. What is the range of pH values that this solution could be?

16. What is the colour of phenolphthalein in stomach acid?

17. A lifeguard comments that swimmers have been complaining that they have a burning sensation in their eyes burning after swimming. What two things would you suggest the lifeguard test for?

Communication C

18. Write a set of instructions on how to identify a binary compound as either an ionic compound or a molecular compound when the chemical formula is given. Write another set of instructions for when the name is given.

19. Create a graphic organizer showing what you know about the reactants and products of each type of chemical reaction that you have learned about this unit.

20. Make a diagram to show the emissions from an industrial plant that contribute to acid precipitation. Also show how scrubbers reduce these emissions. Include the reactions that are involved.

21. Would you be willing to pay slightly more for some products if it meant that manufacturers could reduce their pollution? How effective do you think this change would be in practice? Gather responses from your friends and family, and make a visual summary of your findings.

Unit 2 Review

Application A

22. Copper is widely used for water pipes. Suggest reasons for using copper rather than another metal, such as lead, zinc, or iron.

23. Water-soluble mercury compounds, such as mercury(II) nitrate, are particularly dangerous because they are easily spread through an ecosystem via waste water. One way to remove mercury(II) nitrate from waste water is to add sodium sulfate.

a. Write the chemical formulas for mercury(II) nitrate and for sodium sulfate.

b. Predict what type of reaction will occur based on the reactants. Write a balanced chemical equation for the reaction.

c. Infer the state of the product that is composed of mercury. What would likely be the next step in the clean-up process?

24. Research the major sources of air pollution in your community. Is any of this pollution controlled in any way? What might be the human and economic costs for your community to clean up this pollution? Create a presentation aimed at your local town council.

25. In a train derailment, about one third of a tank of sulfuric acid leaked into a nearby lake. Once the spill had been contained and cleaned up, environmental scientists found that the pH of the lake was normal and had not changed at all. How could this have happened?

Use the table below to answer questions 26 to 28.

26. Analyze the data in the table below. What trend do you see in the emissions from each source?

27. A news agency reports that SO_x emissions from a particular source increased by nearly four times between 1990 and 1995.

a. Which source is the report referring to?

b. What questions could you ask to help you get a more complete picture of the situation?

28. Over the last 20 years, new regulations and technologies have been developed to help reduce SO_x emissions.

a. Create a pie graph to represent the data in the table for 1985. Create a second pie graph to represent the data for 2005.

b. Analyze the differences between your graphs, and write a summary of the changes you observe.

1985–2005 Historical SO_x Emissions for Canada (in tonnes)

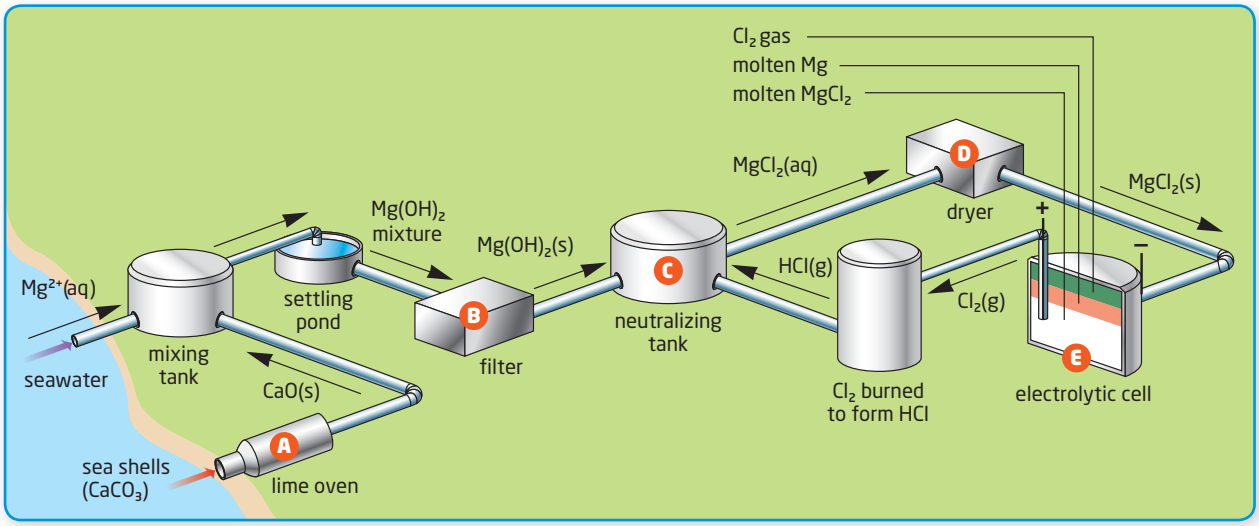
Source	1985	1990	1995	2000	2005
Industrial	2 670 956	2 269 455	1 763 115	1 524 723	1 417 826
Non-industrial (fuel combustion and electrical power generation)	879 113	746 446	566 465	669 097	576 690
Air and ground transportation	172 873	181 828	150 472	122 446	110 409
Incineration	2 779	3 201	3 105	2 790	2 079
Miscellaneous	99	5	3	4	1
Agricultural/mining	4 503	4 401	2 740	1 691	1 712
Natural (forest fires and biological and geological sources)	200	138	549	158	89

Literacy Test Prep

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

Magnesium and its compounds have numerous applications in the world around you. If you have ever flown in a jet airplane, driven in a car, or enjoyed a fireworks display, magnesium has affected your life. In addition, magnesium is a nutrient that your body needs for performing life functions, such as releasing energy from food. Compounds such as magnesium oxide are used to make fertilizers and insulation for pipes, to refine sugar, and to treat waste water.

The diagram below shows how magnesium is obtained commercially from seawater, using a technique called the Dow process. The raw materials are seawater, sea shells, and hydrochloric acid. Examine the diagram, and use it to answer questions 29 to 34.



Multiple Choice

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

29. Magnesium is obtained using a method called the

a. seawater process **c.** magnesium process

b. Dow process **d.** sea-shell technique

30. The raw materials that are used to obtain magnesium are

a. magnesium chloride and calcium oxide

b. sea shells, seawater, and chlorine gas

c. sea shells and sodium hydroxide

d. hydrochloric acid, seawater, and sea shells

31. Which chemical comes out of the neutralizing tank and is used for isolating magnesium?

a. $MgCl_2(aq)$ **c.** $Mg(OH)_2(s)$

b. $MgCl_2(s)$ **d.** HCl(g)

32. At which step in the diagram is magnesium metal obtained?

a. E **c.** C

b. A **d.** D

33. The purpose of the information in the first paragraph is to

a. encourage the reader to buy magnesium

b. provide a summary of how magnesium is produced

c. inform the reader about the different uses of magnesium

d. highlight the use of seawater in the production of magnesium

Written Answer

34. Summarize this selection. Include a main idea and one relevant point that supports it.