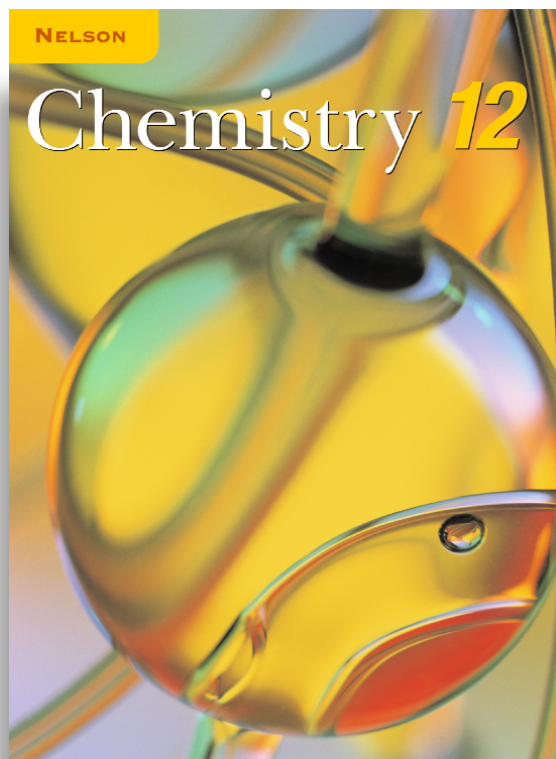




Chemistry 12

Specifically developed for the
Chemistry, Grade 12, University
Preparation (SCH4U) Curriculum

Authors

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Program Goals

1 To ensure a thorough and comprehensible treatment of all content and process expectations in the SCH4U curriculum

- Complex chemistry concepts are presented in a clear, understandable fashion
- Important concepts, such as thermodynamics, are treated in greater depth than specified in the curriculum

2 To equip students with the independent learning, problem solving and research skills essential for success in post-secondary studies

- Self-contained and self-explanatory lessons
- A variety of self-evaluation and self-checking strategies
- A mature design similar to what students will experience with first year university/college texts
- The placement of lab activities at the end of chapters parallels the formal separation of theory and labs in university courses
- Extension and web link strategies provide opportunities to hone individual research and study skills

3 To acknowledge the science background and level of preparation of students entering this new course

- A wealth of diagnostic, pre-testing activities
- Regular practice, assessment, and remediation opportunities
- A chemistry appendix with a review of key Grade 11 concepts

4 To support busy teachers with the implementation and administration of this new curriculum

- Student lessons accommodate independent learning
- A comprehensive array of planning and assessment tools reduce lesson preparation time
- Access to a variety of different instructional approaches

Brief Table of Contents

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Chapter 7: Chemical Systems and Equilibrium

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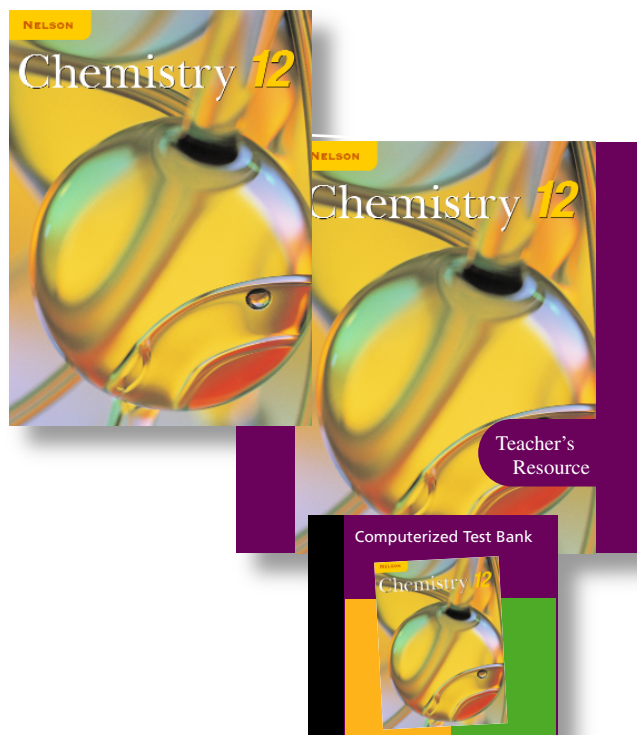
Skills

Reference

Answers

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Components

Student Text (print and CD-ROM)

0-17-612145-5

Teacher's Resource Binder (print, CD-ROM, and web-based)

0-17-625959-7

Solutions Manual

0-17-625958-9

Lab and Study Masters

0-17-625960-0

Computerized Assessment Bank (CD-ROM)

0-17-625961-9

Nelson Chemistry 12 Website

www.science.nelson.com

Evaluation Copies Available Spring 2002!



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UNIT 1: ORGANIC CHEMISTRY

Chapter 1 – Organic Compounds

Section 1.2 questions

p. 23

Question 5

- a. Use the information in *Table 3*, to plot a graph showing the relationship between the number of carbon atoms and the boiling points of the alkanes. Describe and propose an explanation for the relationship you discover.
- b. Research a use for each of the first 10 alkanes, and suggest why each is appropriate for this use.

[Summary of the Properties and Uses of Hydrocarbons](#)

A table containing information about a dozen hydrocarbons, and a brief discussion of their reactivity trends. This AUS-e-TUTE site has been created by science teachers.

[Hydrocarbons: Alkanes and Alkenes](#)

A table containing links to general information about hydrocarbons, especially alkanes and alkenes, along with links to information about certain molecules. This site belongs to a group of websites from the United Kingdom called the Department of Education's Grid for Learning.

[Boiling Points of Alkanes](#)

A small table demonstrating increasing boiling point for larger hydrocarbon chain lengths.

[Octane and Car Engines](#)

From Marshall Brain's How Stuff Works website, this page explains octane in relation to the gasoline that we use in our cars. It also briefly explains recent developments in the gasoline and automobile industries.

[Natural Gas and its Processing](#)

This corporate website provides an introduction to natural gas, explaining its composition and properties. It then explains how natural gas is extracted, de-contaminated, and fractionated into its

various components.

[Organic Chemistry: An Introduction](#)

From VisionLearning, an educational web portal, this site provides a excellent overall introduction to organic chemistry. It begins with the properties of carbon, and moves gradually through alkanes, alkynes, isomerism, and the importance of functional groups.

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Section 1.3 questions

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Question 7

TNT is an explosive with a colourful history (*Figure 5*). Research and report on who discovered it, and its development, synthesis, uses, and misuses.

[Detecting Explosives](#)

From the Sailor Research Group of the University of San Diego, this site actually addresses the development of detectors for explosives. In doing so, it mentions some of the properties of TNT that make it a good explosive.

[The Commercial Explosives Industry](#)

This page, from the Institute of Makers of Explosives (IME), describes the social and technological history of explosives, specifically explaining the impact that advances in explosive technology have had in our daily lives.

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Explore an Issue

p. 35

Role Play: Can We Afford Air Conditioning?

Re: CFC's and alternative coolants. "Imagine that a committee is set up to decide whether the new model should have air conditioning using HFC-134a, or no air-conditioning unit at all."

a. Costs can be measured in many ways: financial, social, environmental, political, etc. Choose one way of assessing cost and collect and sort information to help you decide whether the costs of automobile air conditioners are justified.

- b. Select a role for yourself—someone who would be concerned about the kinds of costs that you have researched. Consider how this person might feel about the issue of air conditioning.**
- c. Role-play the meeting, with everyone taking a turn to put forward his/her position on whether the new car model should have air conditioning.**
- d. After the “meeting,” discuss and summarize the most important points made. If possible, come to a consensus about the issue.**

[Industry Pledge on Greenhouse Gases](#)

This page contains a reporter's description of the 1999 meeting of the annual Earth Technologies forum, in which the leaders of many industries came together to discuss emission reductions of sulfur hexafluoride, PFCs, and CFCs.

[Fluorocarbons and Sulphur Hexafluoride](#)

The Web site is dedicated entirely to explaining the effects of fluorocarbons on the environment. Click on topics in the menu on the left to learn about various fluorocarbons, where they are used, and their effect on the environment.

[Cooling Without Warming](#)

Mitsubishi provides this web-page explaining the movement from car air conditioners using CFCs to those using HFCs. It introduces the idea of now moving to carbon dioxide instead of either of the above fluorocarbons, in order to avoid increased greenhouse gas emissions.

[Ontario and Manitoba to Ban CFCs in Cars](#)

This Canadian Press reporter informs us that Ontario and Manitoba will be limiting further use of CFCs, especially in the air conditioners of older cars. The article explains some of the benefits of such a policy, but also mentions criticisms by some environmental groups of the new policy.

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Practice

p. 37

Question 7

Why are some organic halides toxic while others are not? And why are some organisms affected more than others? Use the Internet to find out, using the following key words in your search: bioaccumulation; fat soluble; food chain. Report on your findings in a short article for a popular science magazine or website.

[Sample solution is regarding DDT Bioaccumulation and Biomagnification](#)

This website summarizes the manner in which pollutants enter an

ecosystem, as well as their tendency to concentrate as they move through trophic levels. It provides case studies on DDT and the Long Island Estuary, and mentions various federal acts relating to heavy metal pollution.

[Bioaccumulation](#)

This Oregon State University site defines bioaccumulation, explains its process, and talks about the subject in terms of the dynamic equilibrium that exists both within individual organisms, but also throughout an entire ecosystem.

[Bioaccumulation Studies in Streams](#)

This site provides links to the results of monitoring projects that keep track of certain bioaccumulation markers in certain streams across the United States.

[Sediment Toxicity and Bioaccumulation Testing](#)

Coastal Bioanalysts Incorporated is a company that performs bioaccumulation testing, and in this website they explain the various methods that they use to complete this testing.

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Section 1.4 questions

p. 37

Question 5

Why was mustard gas such an effective weapon, both during World War I and more recently? Research its properties and effects, and what defences have been developed against it.

[Mustard Gas](#)

This researcher at Bristol University in England explains the composition and past use of mustard gas, and then goes on to explore the use of mustard gas as a therapeutic agent for cancer patients. The article also provides many links to other articles and websites that relate to mustard gas.

[Mustard Gas: Toxicity Frequently Asked Questions](#)

This list of frequently asked questions about mustard gas is provided by the Agency for Toxic Substances and Disease Registry. It provides lots of information, especially for someone who thinks they might have been exposed to mustard gas.

[Mustard Gas Exposure and Long-Term Health Effects](#)

The Department of Veteran Affairs provides this Fact Sheet regarding the long-term effects of mustard gas on war veterans.

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Section 1.4 questions

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Question 6

Shortly after the connection was made between the “hole” in the ozone layer and the release of chlorofluorocarbons, many manufacturers stopped using CFCs as propellants in aerosol cans.

- a. Research what alternatives were developed, and the effectiveness of each in the marketplace. Are the alternatives still in use? Have any of them been found to cause problems?**
- b. Design a product (one that must be sprayed under pressure) and its packaging. Plan a marketing strategy that highlights the way in which your product is sprayed from the container.**

[Aerosols in the Stratosphere](#)

This website provided by the United States Environmental Protection Agency (EPA) explores the link between aerosols in the stratosphere and ozone depletion. It not only provides useful graphs, but also several links to other EPA pages with information about ozone depletion.

[Aerosol Propellants](#)

This information page is provided by the Alliance for Responsible Atmospheric Policy. It explains the preponderance of aerosol products in consumer goods, and proposes that substituting HFCs into such products is the environmentally-responsible solution.

[Aerosol Propellants](#)

This page is part of a series entitled, "The Plain Man's Guide to Aerosols." It explains how aerosol propellant cans work, and introduces the various propellant liquids and gases that are used within them.

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Practice

p. 45

Question 10

- a. Research the reactions, along with the necessary conditions, that take place in a methanol-burning car engine.**
- b. What are the advantages and the disadvantages of methanol as a fuel, over more conventional gasoline or diesel fuels.**
- c. Give arguments for and against the implementation of a law requiring that all cars in Canada should be adapted to burn methanol.**

[Methanol: The Clear Alternative](#)

This site has been developed by the Methanol Institute to advertise

the first vehicle to make a cross-country trek in a methanol fuel-cell car. It provides links to more information about the trek, as well as links to other news and information items about methanol-powered cars.

[Methanol Vehicles](#)

Maintained by the Alternative Fuels Data Center, this site provides many useful specifications regarding methanol vehicles. It also provides links to practical information regarding all alternative-fuel vehicles.

[The Alcohols - Ethanol and Methanol](#)

This site belongs to a group of Transportation Energy websites managed by EnergyQuest. Along with lots of information about alcohol-powered vehicles, there are many links to other sites with information about alternative fuels.

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Section 1.5 questions

p. 48

Question 9

Alcohols have gained increased popularity as an additive to gasoline, as a fuel for automobiles. “Gasohols” may contain up to 10% methanol and ethanol, and are considered more environmentally friendly than gasoline alone.

- a. Write a balanced chemical equation for the complete combustion of methanol and ethanol.**
- b. Although methanol is less expensive to produce, ethanol is blended with methanol in gasoline. This is because methanol does not mix well with gasoline, and ethanol is used as a co-solvent. Explain, with reference to molecular structure, why ethanol is more soluble than methanol in gasoline (which is mostly octane).**
- c. Methanol and ethanol are considered to be more environmentally friendly than gasoline. Research, and explain why.**
- d. When small amounts of water are present in the gasoline in the gas lines of a car, the water may freeze and block gasoline flow. Explain how using gasohol would affect this problem.**

[Ethanol General Information](#)

This site is maintained by the Alternative Fuels Data Center. It provides essential information on the potential use of ethanol as an energy source in transportation. It provides many links to the major industry players that recommend ethanol use in vehicles.

[Ethanol Information](#)

Hosted by the American Coalition for Ethanol, this site advocates the many benefits of blending ethanol with the currently-used form of gasoline. It outlines the economic, agricultural, energy, and environmental benefits of making the change.

[Global Climate Benefits of Methanol](#)

This page hosted by the Methanol Institute briefly explores the climatic advantages that might result by the adoption of methanol as an energy source for vehicles. To access information on methanol fuel cells, click on "fuel cells" in the middle of the page and then click on "fact sheets."

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Section 1.6 questions

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Questions 8

Many organic compounds have been in everyday use for many years, and are commonly known by nonsystematic names. Make a list of common names of organic compounds found in solvents, cleaners, and other household items. Conduct research using electronic or print resources to find out the chemical name of five of these compounds, identify the functional groups that are present, and discuss the useful properties that these functional groups may impart to the compound.

[Products for Treatment for Condensation on Historic Glass and Storm Sash](#)

This page belongs to a group of websites dedicated to "old-house enthusiasts," and though its primary purpose is to describe methods for cleaning glass, it also mentions in some detail the use of common names to describe commonly used organic cleaning solvents.

[CHCE's HealtheHouse](#)

This Web site lists compounds around the house that can be harmful to children. Included on this list is a number of common household cleaners, which have an organic chemical base.

[Sources of Indoor Air Pollution - Organic Gases](#)

This web page from the United States Environmental Protection Agency details the harmful effects of some common cleaners found around the house.

[Chemical Hazards in the Home: Household Cleaners and Polishes](#)

This pamphlet goes over the health and environmental hazards of a number of household cleaners. Details about furniture polishes, drain openers, and oven cleaners are included here.

[Chemicals in Home and Work Environments](#)

This catalogue describes chemicals that are found in home and workplace environments. Chemical and common names are provided, along with a description of uses and occurrences of these substances in solvents, plastics, and gases.

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Section 1.6 questions

p. 57

Question 9

The smell of formaldehyde was once common in the hallways of high schools, as it was used as a preservative of biological specimens. This use has largely been discontinued.

- a. What is the IUPAC name and structure of formaldehyde?**
- b. Why was its use as a preservative curtailed, and what substances are being used in its place?**

[Formaldehyde](#)

This encyclopedia.com entry provides a brief entry describing the chemical formaldehyde and its uses.

[Methods of Fixation and Preservation](#)

This site is managed jointly by the United States Antarctic Program (USAP) and the National Museum of Natural History (NMNH). The page describes the various mixtures that are used to preserve specimens, with several recipes for making them, some with formaldehyde, some without.

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Section 1.6 Questions

p. 57

Question 10

In cases of severe diabetes, a patient's tissues cannot break down glucose, and, instead, the body breaks down fat for its energy. The fats are broken down in the liver and muscles, producing several compounds called "ketone bodies," one of which is acetone.

- a. The acetone produced in this process is carried in the blood and urine. Explain why acetone is soluble in these aqueous solutions.**
- b. When fats are the main source of energy production, there is an overproduction of ketone bodies, leading to a condition called ketosis. A patient with untreated diabetes may have a blood**

concentration of acetone of 20 mg/ 100 mL.

Convert this concentration to mol/L.

c. Acetone is volatile and is exhaled with the breath. Suggest a reason why, like untreated diabetic patients, people who are severely starved or dieting may have a smell of acetone on their breath – a diagnostic symptom of ketosis.

d. Other ketone bodies lower blood pH, causing a condition called acidosis, which can lead to coma and death. Research the symptoms and effects of ketosis and acidosis and how these conditions may be avoided.

[Diabetic Ketoacidosis](#)

This page from MEDLINEplus details the causes, symptoms, and possible treatments of diabetic ketoacidosis.

[Diabetic Emergencies and Anaesthesia](#)

This 4um.com website provided by Pat Neligan provides an excellent overview of diabetic emergencies, first by describing diabetes in general, and then by relating these facts to the types of diabetic emergencies that might result with anaesthesia.

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Practice

p. 63

Question 10

Some cosmetic facial creams contain an ingredient manufacturers call “alpha hydroxy,” which is designed to remove wrinkles. These compounds are carboxylic acids that contain a hydroxyl group attached to the C atom adjacent to the carboxyl group.

- Explain why “alpha hydroxy” is an incorrect name for any compound.
- The alpha hydroxy acids in cosmetics may include glycolic acid, lactic acids, malic acid, and citric acid. Research and draw structural diagrams for these compounds.
- In order to be absorbed through the skin, a substance must have both polar and nonpolar components. Explain why these alpha hydroxy acids are readily absorbed through the skin.
- Over-the-counter creams may contain up to 10% alpha hydroxy acids, while 25-30% concentrations are used by cosmetologists for “chemical peels.” In each case, the ingredients cause the surface of the skin to peel, revealing younger looking skin. Suggest reasons why physicians recommend daily use of sun protection

to accompany the use of these facial creams.

[Dupont Glycolic Acid](#)

This commercial website managed by DuPont provides the technical specifications for glycolic acid, along with a full set of information including common uses, safety, storage, and packaging.

[Alpha Hydroxy Acids for Skin Care](#)

This article describes alpha hydroxy acids and lists what ingredients are commonly included in alpha hydroxy skin creams. It also describes possible harmful effects that these creams can have and ways to avoid these effects.

[Lactic Acid](#)

This site describes lactic acid, its biochemical role in the body, its chemical structure, and its uses.

[Malic Acid](#)

This site describes malic acid, its physical properties, its chemical structure, and how it can be converted into lactic acid through a process called malolactic fermentation.

[Citric Acid](#)

This encyclopedia.com entry on citric acid describes the molecule's structure and properties. It also mentions, places where citric acid is found and processes in which citric acid plays an important role.

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Section 1.7 questions

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Question 8

Working with a partner or a small group, brainstorm and list several occupations that require a knowledge of alcohols, carboxylic acids, or esters. Research one of these careers and write a brief report on the main strengths and qualities needed, academic training, and job opportunities in the field.

[Cool climate Oenology and Viticulture Institute](#)

This institute's website introduces the group's partnership with the Wine Council of Ontario and the Ontario Grape Growers Marketing Board.

[Links to Ontario Wineries](#)

This page lists all Ontario Wineries.

[Perfumes](#)

This site provides a very interesting description of the evolution of the perfume industry in France. Along with economic descriptions, it also provides a social history of such long-lasting, successful companies like Chanel.

[The History of Perfume](#)

This website provides links to pages that trace the evolution of perfume back to the ancient Medes and Persian, right up until the 1990s.

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Section 1.7 Questions

p. 68

Question 9

Tannic acid, originally obtained from the wood and bark of certain trees, has for centuries been used to “tan” leather.

- a. Give IUPAC name and chemical formula for tannic acid.**
- b. What effect does tannic acid have on animal hides? Explain your answer with reference to the chemical reactions that take place.**

[Leather and Tanning](#)

This page describes tannic acid, its molecular formula and weight, its properties, and its applications in medicine and food preparation.

[Leather Tanning](#)

This site explains the origins of leather and the tanning process. The cleaning, depilation, sweating, liming processes, as well as the two methods of tanning are described.

[History and Process of Leather](#)

This page describes the history of leather manufacturing and the processes involved in the treatment of hide, including fleshing, curing, pickling, and tanning.

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Section 1.9 Questions

p. 82-83

Question 4

The flavour of almonds is obtained from benzyl methanal, also called benzaldehyde. “Natural” almond flavour is extracted from the pit of peaches and apricots, and may contain traces of the poison hydrogen cyanide.

- a. Write a structural diagram for benzaldehyde.
- b. Write equations for a series of reactions in the synthesis of benzaldehyde from an ester.
- c. Research and describe the toxicity of the reactants listed in (b), and compare the toxicity to that of hydrogen cyanide. In your opinion, do your findings substantiate consumer perception that “natural” products are always healthier than their “artificial” counterparts.

[Smell Database: Hydrogen Cyanide](#)

This University of Berkeley website provides some quick information about hydrogen cyanide, including its overall chemical properties.

[Hydrogen Cyanide](#)

This Bartleby.com website contains an entry from the Columbia Encyclopedia, Sixth Edition, about the chemical, hydrogen cyanide. It describes some overall properties, the chemical's uses, and information about where it can be found in nature.

[Chemical Fact Sheet: Benzaldehyde](#)

This page provided by Spectrum Laboratories consists of a large table with the properties of, and facts about, benzaldehyde.

[Materials Safety and Data Sheet \(MSDS\): Benzaldehyde](#)

This "MSDS Sheet" is the standardized information summary about benzaldehyde, and includes information useful to a lab: safety considerations, physical properties, and reactivity of the chemical.

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Section 1.9 Questions

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Question 5

Quinine is a fairly effective treatment for malaria, a mainly tropical disease that kills and incapacitates millions of people every year. Quinine has a bitter taste and was mixed with lemon or lime to make it palatable; it was later included as a component of a beverage called tonic water.

- a. Tonic water contains approximately 20 mg of quinine per 375-mL can; the dosage required for the treatment of malaria is approximately six 300-mg tablets per day. In your opinion, would drinking tonic water be an effective approach to the treatment of malaria? Explain.
- b. Refer to the structural diagram of quinine on p. xx, and explain why quinine is soluble in water.

c. Research the effectiveness of quinine as an antimalarial agent from the early 1800s to the present. Origins:

[Quinine](#)

This page from Rain Tree Nutrition gives a detailed history about quinine and its application as an antimalarial drug.

[History of Malaria](#)

This page provides an in-depth look at malaria. It includes several useful diagrams including a map showing malarial prevalence around the globe, a picture of the human body and the mosquito vectors that bear the disease, and slides of the actual disease-causing parasite.

[Quinine](#)

This page is part of a series entitled, "Molecules of the Month." It provides a brief overview of quinine, the first drug ever used to combat malaria.

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Investigation 1.5.2: Trends in Properties of Alcohols

p.86

Evidence

c. Using a print or electronic reference source, find the melting point and the boiling point of each of the alcohols listed, and record the information in your table. [alcohols – ethanol; 1-propanol; 1-butanol]

[Alcohols](#)

This "Journey into Science" webpage uses examples of molecules, a chart and several questions to provide an introduction to various alcohols.

[Safety \(MSDS\) Data for 1-Butanol](#)

Read about the safety precautions for handling of 1-butanol.

[Safety \(MSDS\) Data for 1-Propanol](#)

Read about the safety precautions for handling of 1-propanol.



Investigation 1.7.1: Properties of Carboxylic Acids

p. 88

Evidence

d. Using print and electronic resources, obtain the melting point and boiling point for acetic acid and stearic acid, and record them in the table.

[Safety \(MSDS\) Data for Acetic Acid](#)

Read about the safety precautions for handling of acetic acid.

[Safety \(MSDS\) Data for Stearic Acid](#)

Read about the safety precautions for handling of stearic acid.

[Stearic Acid](#)

This site contains a table with some quick facts about stearic acid.

[Material Safety Data Sheet \(MSDS\): Glacial Acetic Acid](#)

An MSDS contains standard and comprehensive information about chemicals, especially regarding safety considerations, physical properties, and reactivity, all of which are important pieces of information when using acetic acid in a lab.



Chapter 1 Review

p. 97

Questions 15

Use print or electronic resources to obtain the molecular structure of glucose, glycerol, and ethylene glycol. All three compounds have a sweet taste.

- a. Predict the relative melting points and boiling points of rubbing alcohol, ethylene glycol, glycerol, and glucose. Give reasons for your answer.**
- b. Predict the solubility of each of these compounds in water, and in gasoline. Give reasons for your answer.**
- c. Ethylene glycol is toxic and is used as an antifreeze in automobile radiators. Suggest a reason why car antifreeze must be stored safely and spills must be cleaned up.**
- d. Do the structures of these three compounds support the hypothesis that taste receptors respond to functional groups in the compounds tasted? Explain.**

[Glucose Structure](#)

This page contains a 3-dimensional view of the glucose molecule.
[**Please note: You will likely need to download additional software to see the picture.]

[Carbohydrates](#)

This site is the result of a partnership between Kennesaw State University and the United States' National Science Foundation. It provides a brief overview of carbohydrates, and talks about such molecules as sucrose, cellulose, and glycerol.

[Material Safety and Data Sheet: Ethylene Glycol](#)

An MSDS contains standard and comprehensive information about chemicals, especially regarding safety considerations, physical properties, and reactivity, all of which are important pieces of information when using ethylene glycol in a lab.



Question 16

The distinction between “natural” and “synthetic” products is usually based in the source of the product, whether it is made by living organisms or by a laboratory procedure. Sometimes, the product is in fact the same, but the distinction is made in the way the product is processed. For example, when bananas are dissolved in a solvent and the flavouring extracted, the pentyl ethanoate obtained is labelled “natural flavour.” When pentyl ethanoate is synthesized by esterification of ethanoic acid and pentanol, it is labelled “artificial flavour.”

- a. Write an equation for the synthesis of pentyl ethanoate.**
- b. In your opinion, what criteria should be used to distinguish a ‘natural’ product from a ‘synthetic’ product?**
- c. Research the differences in the source and processing methods of vanilla flavouring. Write a report on your findings.**

[Vanilla Extracts and Flavors](#)

This website from the Vanilla.Company provides a very comprehensive description of facts relating to vanilla, from general information to specific details regarding various vanilla products.

[Preparation of ortho-Eugenol](#)

Ortho-eugenol belongs to a class of compounds called vanilloids, and this site describes the molecule, and explains how to prepare it in a lab.

[The Determination of Vanillin in Vanilla Extract](#)

This page is provided by the University of Malta's Department of Chemistry--it outlines a very useful procedure for analysing the contents of vanilla extract.

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UNIT 1: ORGANIC CHEMISTRY

Unit 1 – Performance Task and Review

Unit 1 Review

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Question 23

The compound p-aminobenzoic acid (PABA) is the active ingredient in some sunscreen lotions.

- a. Draw a structural diagram for PABA.**
- b. Predict some properties of PABA such as solubility, melting point, and chemical reactivity.**
- c. Research, using electronic or print resources, the properties of PABA, explanations of its role against UV radiation, and any possible hazards in its use to the wearer or to the environment.**

[Facts About Sunscreens](#)

This site belongs to the "Patient Information" group of sites of the American Academy of Dermatology. It contains a very helpful list of questions and answers that explain in detail how sunscreen works.

[Sunscreens and Sunburns](#)

This Altruus Biomedical Network site explains the process of sunburning, as well as the mechanism of sunscreen action. It also details the many ingredients (including PABA) that might be found in sunscreens, and evaluates their effectiveness.

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Question 24

Research the use of chlorinated hydrocarbons as solvents in the removal of contaminants from microchips in the manufacture of computers. Write a report discussing

- a. any hazards in the use of chlorinated hydrocarbons; and**
- b. other polymers that have been used by the**

computer industry as cleaning agents for microchips.

[Micell Technologies, Inc.](#)

This web-page explains the challenges faced by Micell Technologies in developing a new system for dry-cleaning, using liquid carbon dioxide. It also discusses the potential advantages for the environment if such a change in the industry was to be made.

[Environmental Issues in Semiconductor Manufacturing](#)

The middle of this web-page, maintained by the (American) State Science & Technology Institute, addresses the industry concern that perhaps too much water is being used to clean semiconductors, and that perhaps alternatives to glycol ethers can be found for cleaning solvents.

[Environment-Friendly Chip Design](#)

A part of the NewsFactor Network, this article explains the new techniques that several different companies are working out to make the manufacturing of computer chips and semiconductors more environmentally-friendly.

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Question 25

There is ongoing research in the development of polymeric materials for use in dentistry and related fields, such as cranial and facial restoration. Polymers used to make dental impressions, for example, require certain properties, including low solubility, high tensile strength, and a high softening temperature.

Research current practice and recent advances in the use of organic polymers in the dental industry and the dental profession. Write a report on your findings, covering the following topics.

- **The desired properties of dental polymers and the shortfalls of available materials**
- **The key structural features of the monomers in current and prospective dental polymers**
- **The rate and degree of the formation of crosslinks between polymer chains, and properties of the structural matrix formed**
- **The pros and cons of different methods of initiating the polymerization process**
- **The role of hydrogen bonding on the physical and mechanical properties of the polymer**

[Dental Polymers](#)

This website is provided by the Polymers Division of the National Institute of Standards and Technology. It describes a project on

which the NIST is embarking to provide a knowledge base for the dental profession regarding polymeric dental materials.

[Laser Curing Dental Polymers](#)

Scroll down to item #4 on this list of new research projects sponsored by the Delaware State University. The described project will attempt to prevent dental fillings detaching from the tooth cavity wall due to shrinkage.

[Why Not White Fillings](#)

This website provides an instructive list of questions and answers regarding "white fillings," providing a balanced view of their advantages and disadvantages as compared with traditional silver fillings.

[Improving the Treatment of Cavities](#)

This article appears in an online journal called "The Mission," sponsored by the University of Texas at San Antonio. It discusses the use of newer, modern fillings, and their effectiveness in preventing cavities. The article also includes some helpful diagrams.

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Question 26.

Various chromatographic methods are used for the separation of mixtures into their individual components. The mixture is adsorbed onto a stationary support such as a gel, and the compounds are separated by differences in polarity and molecular size. Research one of the following aspects of chromatography, and write a report to present your findings.

- **The selective use of solvents in liquid chromatography to separate compounds with differences in solubility in the solvent**
- **The structure and properties of proteins and nucleic acids that allow their purification through electrophoresis**
- **The features of a gas chromatography system used in the analysis of trace amounts of organic substances such as illicit drugs or pesticides**
- **The structure and properties of synthetic polymers, such as polyacrylamide, used as stationary support in gel electrophoresis**

[High Performance Liquid Chromatography](#)

Provided by a research group at the University of Kentucky, this website introduces HPLC and provides several links that can be followed for explanations regarding the technique's history, operation, manufacturing, and troubleshooting--an excellent and detailed overview.

[Gas Chromatography](#)

This University of Akron web-page describes several aspects of gas chromatography, and includes several diagrams and pictures of the machinery and the process.

[Liquid Chromatography](#)

This University of Akron website introduces the process of liquid chromatography, and describes the process using several easy-to-read slides along with diagrams and pictures.

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Question 30

Polymers can be made from other substances, besides organic monomers. One of the more familiar is silicon. Research its structure, manufacture, properties, and uses. Conclude with an example of a situation in which the use of silicone has provided some benefits and some drawbacks.

[What is Silicone?](#)

This site is maintained by the Independent Review Group in the United Kingdom. This page distinguishes silicone from various other chemical compounds like silica and silicon. The basic physical and chemical properties of each of these chemicals is explained.

[Silicone Chemistry](#)

This excerpt comes from a book, entitled, "Safety of Silicone Breast Implants," and includes a brief overview of silicone materials, as distinguished from silicon and silica.

[Specialty Silicone Products, Inc.](#)

This is the corporate website of a company that researches and manufactures several silicone products.

[What is a Silicone?](#)

This corporate website of Sil-Tech explains briefly what silicone is.

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UNIT 1: ORGANIC CHEMISTRY

Chapter 2: Polymers–Plastics, Nylons, and Food

Section 2.1 questions

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Question 11

Natural rubber is made from resin produced by the rubber tree, *Hevea brasiliensis*. Research the commercial production and use of natural rubber, and the circumstances that stimulated the development of synthetic rubber. Write a brief report on your findings.

[The History of Natural Rubber](#)

This page is sponsored by the Tun Abdul Razak Research Centre. It provides a fascinating history of rubber--starting from Columbus bringing it to Europe from the West Indies.

[A Brief History of Rubber](#)

From the Rubber Association of Canada, this site provides in chart-form a timeline of major events relating to rubber and its past uses.

[Charles Goodyear and the Strange Story of Rubber](#)

Read about Charles Goodyear, the man credited with discovering the vulcanization of rubber.



Section 2.3 questions

p. 116

Question 2

Research and provide examples of the use of organic chemistry to improve technical solutions in the medical field. Write a report on one of the examples you found. Include in your report a description of the problem to be solved, existing technical solutions, and the role of organic chemistry in the improved solution. A few examples are provided as a starting point for your research.

- Drug delivery systems, e.g., nicotine patches, estrogen patches, gel capsules for timed release
- Artificial flexible joints
- Medical textiles, e.g., adhesives
- Medical equipment, e.g., materials for angioplasty
- Polymers as UV blockers

[The Technology Behind Drug Patches](#)

This website is found in the pages of The Chemical Institute of Canada. It briefly discusses the mechanism of transdermal drug-delivery, and explains how it is used in drug patches. It also introduces a company, Pharma Patch, that is based in Toronto--the company studies and develops these devices.

[Sulfamate Technology](#)

Jenapharm is the German company that maintains this website. The site briefly discusses the use of estrogen sulfamates as estrogen-therapy, since these drugs eventually become estrogen in the body. It includes a helpful schematic diagram showing the drug's path through the body.

[UV Absorption and Stabilizers](#)

EPEA is a scientific consultancy that espouses "Eco-effectiveness." This website lists the various auxiliary services that the company provides, including "UV absorption and stabilizers."

[Puncture-Resistant Angioplasty Balloons Developed](#)

Medical DeviceLink is a collection of websites devoted to the medical device industry. This specific site discusses a recent development by the company, Advanced Polymers Inc., who have developed puncture-resistant high-pressure angioplasty balloons by using a polymer coating.

[What are Biomedical Textiles](#)

This website is maintained by the Biomedical Textiles Research Centre of the Heriot Watt University in Scotland. It provides a brief introduction to biomedical textiles, focusing on practical matters such as their function, cost, and application.

[Top](#)

Explore an Issue – Take a Stand: Will That Be “Regular” or “Diet”?

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Effects of Aspartame.

- Research some of these studies, writing brief summaries of the arguments for and against the use of aspartame or another food substitute or additive (e.g., artificial flavour, food colour).**
- In a small group discuss the factors that you would consider in reviewing any such scientific study to determine the validity of the results.**
- Analyze the risks and benefits of the use of your chosen food**

substitute or additive. Write a report on the results of your analysis, and make a recommendation on its use, with supporting arguments.

[The Aspartame Home Page](#)

This site aims to "provide comprehensive information about aspartame and serve as a reference for sound, scientific data." It contains links to several sites with various categories--they provide a balanced look at aspartame.

[Artificial Sweeteners](#)

This page makes up part of the National Cancer Institute (U.S.) "Cancer Facts" group of websites. It briefly discusses the evidence and sources for connecting artificial sweeteners to cancer. Its overall message is that studies have neither proven the link between them, nor ruled out a connection.

[The History, Synthesis, Metabolism and Uses of Artificial Sweeteners](#)

From Emory's Center for Interactive Teaching, this site discusses artificial sweeteners in terms of their purpose, history, pros/cons, chemical structure and synthesis, and their metabolism in the body. It contains many helpful diagrams for the organic chemistry student.

[Saccharin: How Sweet It Is](#)

This site is maintained by the Calorie Control Council, and serves to promote and defend the use of saccharin. It contains links to pages with information about the history of saccharin and public policies towards it, studies related to saccharin, and a number of links to additional information about saccharin available from other sources.

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Section 2.4 questions

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Question 9

Research the secondary and tertiary structures of one of the following proteins:

- a. fibrinogen, the protein involved in blood clotting;**
- b. collagen, a connective tissue;**
- c. cytochrome c, used in electron transport;**
- d. myoglobin, an oxygen-binding protein;**
- e. myosin, a muscle protein.**

Present your findings in a report that includes a

description of the secondary and tertiary structures that make the protein ideally suited to its function.

[Collagen Structure](#)

This web page contains a detailed description of collagen's structure, along with a diagram that shows a 3-dimensional approximation of what the collagen molecule looks like.

[Peptides](#)

This page belongs to a group of Medical Biochemistry pages for a medical school. It discusses protein structure, and then details the various options one has for analysing proteins. A quite advanced, but thorough, Web site.

[Collagen](#)

From the Protein Data Bank, this website provides an excellent overview of collagen, describing not only its structure, but also its relationship to things like vitamin C and gelatin.

[Cytochrome c](#)

This page contains an image of cytochrome c, with a caption that explains the use of colour in the schematic diagram.

[Cytochromes c](#)

This advanced site from the Scripps Institute describes the major classes of cytochrome c molecules, and includes several images and diagrams showing the 3-dimensional structure of the molecule and its functional groups, such as the heme group.

[Myoglobin](#)

This article was written by an assistant professor at Kent State University. He briefly discusses myoglobin's function, and then goes on to explain its various levels of structure. The site includes a diagram, however it is only visible if you have CHIME software installed on your computer.

[Myoglobin](#)

This Interactive Biochemistry site briefly discusses myoglobin's function, and then goes on to explain its various levels of structure. The site includes a diagram, however it is only visible if you have CHIME software installed on your computer.

[Myoglobin](#)

This site discusses in detail myoglobin's function, and then goes on to explain its various levels of structure. The site includes a diagram, however it is only visible if you have CHIME software installed on your computer.

[Myosin and Associated Muscle Proteins](#)

This page belongs to the Neuromuscular Disease Center of the Washington University School of Medicine. The site provides a very advanced look at myosin, its different types, its composition, and its central role in muscles.

[Myosin Structure](#)

A nice, large picture of a myosin molecule. Includes labeling of a few of the molecule's features.

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Question 14

Thalidomide, so harmful when administered as a mix of L and D configurations, has been banned in many countries. However, it is a very versatile and inexpensive drug when the configurations are isolated and used selectively.

- a. Research the current use of thalidomide (if any), and other pharmaceuticals (if any) that are used in its place.**
- b. Compare the costs of using thalidomide with the costs of developing alternative drugs or the costs of having no drugs available.**
- c. Write a brief report addressing the question, “Should thalidomide continue to be banned?” for use in a popular science magazine.**

[Thalidomide](#)

This site contains pictures of, and links to information about, thalidomide. The links contain information about its: first appearance, effects, isomerism, and re-emergence.

[Thalidomide: Should We Risk Another Tragedy?](#)

This BBC News website invites readers to share their views on the potential future use of thalidomide. Several readers have shared their comments.

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Section 2.7 questions

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Question 13

Research the following aspects of linseed oil, and write a report to present your findings:

- a. chemical composition;**
- b. properties;**
- c. common uses;**
- d. safety precautions in its use and disposal;**
- e. classification as natural, organic, or synthetic.**

[Flaxseed Oil](#)

This continuing education handout was produced by a teacher at the University of Southern California. It details flaxseed oil's history, content, pharmacology, and therapeutic applications in a comprehensive Adobe Acrobat (.pdf) file.

[Safety Data for Linseed \(Flaxseed\) Oil](#)

From Oxford University in England, this site outlines safety considerations relating to flaxseed oil, including its physical properties and reactivity.

[Linseed Oil](#)

This site from Purdue University's Center for New Crops and Plants Products provides an overview of linseed oil, and discusses the history of its production.

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Chapter 2 Review Making Connections

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Question 23

Monosodium glutamate (MSG) is a derivative of glutamic acid. It is used widely as a flavour enhancer in canned soups and meats, sauces, and potato chips.

- a. Draw a structural diagram for MSG.**
- b. Could this molecule have two different conformations? Explain.**
- c. research and report on any concerns about the use of MSG in foods.**

[Monosodium Glutamate \(MSG\)](#)

This website from About.com's group of websites explains MSG, beginning with the adverse reactions that result in a minority of the population, and then going on to discuss its use, sources, and composition.

[Food Allergy and Intolerance](#)

A part of the online WebHealthCentre.com, this site discusses allergic reactions, food intolerance, and food poisoning. It explains some of the causes of food allergy/intolerance, and provides information for those that are afflicted by such intolerance.

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UNIT 2: STRUCTURE AND PROPERTIES

Chapter 3 – Atomic Theories

Section 3.1 questions

p. 166

Question 10

Describe some contributions Canadian scientists and/or scientists working in Canadian laboratories made to the advancement of knowledge about the nature of matter.

[Canadian Scientists](#)

This Science.ca website provides pictures of, and information about, notable Canadian scientists in a plethora of different areas of study. It also lists Nobel Prize Laureates, and has several links to the Science.ca group of websites.

[Top](#)

Section 3.1 General Links

[Atomic Theory and Periodicity: Links](#)

This page is full of links to various websites and files that contain information regarding atomic theory basics, including multimedia links to videos and pictures. NOTE: You will likely need multimedia "plug-ins" like Quicktime Player, in order to access some of the multimedia links that are included.

[Science Resources](#)

This website was assembled for the students at Bellerose Composite High School. It includes several websites that list a large number of links to websites about various aspects of science. This site is well organized and looks very useful.

[Top](#)

Section 3.2 General Links

[The Chemical Heritage Foundation](#)

This foundation has set up a "historical research library," through

which it can provide the public with a better understanding of chemistry. Follow the link entitled, "Sites of Chemical and Historic Interest," for links to informative websites.

[The Nobel E-Museum](#)

This high-quality website contains lots of information about past Nobel prize winners, as well as many interactive games and demonstrations that teach useful concepts in science and in other areas.

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Section 3.4 Questions

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Question 11

Read as much as you can from Bohr's original paper about the periodic table. List the content presented in Bohr's writing that you recognize. Approximately how much content is beyond your understanding at this time?

[Atomic Structure, by Niels Bohr](#)

The original article as it appeared in the scientific journal, "Nature," on March 24, 1921.

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Section 3.4 General Links

[Classic Papers from the History of Chemistry](#)

If you've ever wondered how scientists that you have studied shared their information with other scientists, you'll find this website very interesting.

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Section 3.6 Questions

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Question 17

Electron spin resonance (ESR) is an analytical technique that is based on the spin of an electron. What types of substances are analyzed using ESR spectroscopy? State some examples of the uses of ESR in at least two different areas.

[Electron Spin Resonance](#)

This page describes ESR, a dating technique that can be used

repeatedly on the same sample, and which can be used to date things such as tooth enamel.

[Electron Paramagnetic Resonance](#)

This page describes the use of EPR spectrometers to discriminate between very similar chemical samples. The technique can even obtain spectra from living animals and perfused organs.

[Applications of EMR](#)

This page provides a list of all of the fields, from Archaeology to Biology, that make use of EMR spectroscopists.

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Section 3.6 questions

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Question 18

Magnetic Resonance Imaging (MRI) is increasingly in demand for medical diagnosis. How is this technique similar to and different from electron spin techniques? Provide some examples of the usefulness of MRI results. What political issue is associated with MRI use?

[The Basics of MRI](#)

The author of this source is a professor at the Rochester Institute of Technology. The website is a large collection of pages about MRI, organized into 13 chapters. It goes into quite a bit of detail, yet it reads quite easily.

[Magnetic Resonance Imaging](#)

This short encyclopedia.com article briefly explains the basics of MRI.

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Section 3.7 Questions

p. 202

Question 8

Dr. Richard Bader and his research group at McMaster University are well known for their work on atomic and molecular structure. Find out the nature of their work and give a brief, general description of how it relates to quantum mechanics.

[The Electronic Structure of Atoms and Molecules](#)

Written by the renowned Dr. Bader at McMaster University, this resource explains our current understanding regarding the

composition of atoms and molecules with respect to their electrons and configurations. The text is interspersed with many diagrams.

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Section 3.7 Questions

p. 202
Question 9

There are many present and projected technological applications for superconductivity. Research these applications and make a list of at least four, with a brief description of each.

[Superconductivity for Electric Systems](#)

This U.S. Department of Energy website introduces the strategy that is being pursued in order to allow people to use electricity "with near perfect efficiency and much higher capacity." The site contains links to the Department's many online resources.

[Superconductivity for High School Students](#)

Provided by the Oak Ridge National Laboratory, this website contains an excellent and comprehensive resource on superconductors: their fundamentals, applications, chemistry and more. Three demonstrations and four experiments are also explained in detail.

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Section 3.7 Questions

p. 202
Question 10

Research the highest temperature at which superconductivity has been achieved. What substance is used for this highest temperature?

[Superconductors](#)

This non-profit website provides "beginners and non-technical people" with an introduction to the world of superconductors. Includes links to several websites and diagrams.

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Section 3.7 General Links

[The Orbitron](#)

This website from the Department of Chemistry at the University of Sheffield in the U.K. provides images of all of the different electron orbitals that are possible in an atom, with explanations that tie the images to the atomic theory regarding four quantum numbers.

Section 3.8 questions

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Question 4

Use the Internet to write a short report on X-ray crystallography, describing how X rays can be used to give information on structures of solids at the atomic level.

[X-Ray Crystallography](#)

This Encyclopedia.com article provides a brief overview of X-Ray Crystallography.

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Section 3.8 General Links

[How Lasers Work](#)

This "How Stuff Works" website contains a 6-page article explaining how lasers work, from concepts of atomic emission spectra to an explanation of how lasers are classified for safety and regulatory purposes.

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Practice Careers

Choose one of the food and beverage industry, biotechnology, clinical research, environmental research, or the pharmaceutical industry, and use Internet information to write a short report on a career in that area associated with spectroscopy. Include training and education requirement, approximate salary expectations, and employment prospects.

[Job Guide 2003](#)

This Australian website, Job Guide 2003, assists you to search for a specific job or career by prompting you to choose industry groupings or personal interests.

[Science-Related Job Banks / Career Centres](#)

This website contains a large list of links to specialized websites that have job listings for several different careers in science around the world.

[Yahoo Science Employment](#)

This site from Yahoo.com provides a number of links, grouped by

scientific discipline, that lead to listings of specialized job banks in those particular fields.

Science.ca

This Canadian website contains lots of valuable information about Canadian scientists and their contribution. The site also posts questions of the week and allows you to "Ask a Scientist," any question you like.

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Chapter 3 Review

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Question 25

Ernest Rutherford and Frederick Soddy collaborated in researching radioactivity at McGill University (1900-02). Their empirical work completely transformed the understanding of radioactivity, and earned each of them a Nobel Prize.

- a. Research their Nobel Prizes and report on the year of the award, the subject area, and specific contributions cited.**
- b. Describe the effects of their discoveries on our society.**

[The Official Web Site of the Nobel Foundation](http://TheOfficialWebSiteoftheNobelFoundation)

This high-quality website is the entrance into an enormous scientific resource. Of additional interest to the information about Nobel Prize Winners are games and interactive tutorials relating to a wide range of topics.

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UNIT 2: STRUCTURE AND PROPERTIES

Unit 2 – Performance Task and Review

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Question 35

In steel mills and foundries, a device called an optical or wire pyrometer is often used to measure the approximate temperature of steel that is hot enough to glow by its own emitted light. Research and report on the operating principle of this type of pyrometer and refer to Planck's theory of light emission in your explanation.

[Heat Treatment of Steel](#)

This website discusses pyrometers and the heat-treatment of steel. It describes pyrometers that work in different ways with different mechanisms and with different needs for calibration.

Question 28

In DNA, the pairing of nitrogen bases depends on hydrogen bonding between two molecular structures that must be precisely the right size and shape to bring the hydrogen atoms and lone pair of electrons together. Research and report on the names of the nitrogen bases that bond together in a DNA double helix structure; and on how many hydrogen bonds are formed between the two different base pairings.

[Introduction to DNA Structure](#)

This excellent tutorial from the University of Arizona explains the structure of DNA in great detail, but using attractive graphics to demonstrate the various components of the DNA molecule.

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Question 40

Describe a carbon nanotube and some of its properties. How does the bonding within the nanotube molecule compare with other forms of pure carbon? What have scientists been able to do with these tubes? List some potential applications of these

nanotubes.

[A Carbon Nanotube Page](#)

This website provides an overview of the science of nanotubes, followed by several useful lists--of links, books and reviews, references, and commercial suppliers.

[All Aboard the Nanotube](#)

This article appears in WordLink, the magazine of the World Economic Forum. The author describes the potential uses of nanotubes, once their technological capabilities have been realized.

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Question 41

Kevlar is a specialized synthetic material that has some remarkable properties. List some of these properties and describe some different applications. What makes Kevlar so strong? Include some information about molecular structure, shape, and bonding in your answer.

[Brains and Kevlar](#)

This corporate website briefly introduces the material, Kevlar, but you'll have to follow links to other parts of Dupont's website to find information about the science and technology of Kevlar.

[What Makes Kevlar So Strong?](#)

From the Berkeley Lab, this website explains clearly and succinctly, how exactly Kevlar acts as such a strong material. It includes pictures in its description of Kevlar at the atomic level, as well as at the structural level.

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Question 42

Diamond is the hardest material known and it is used in cutting tools for any other substance, including very hard rocks like granite. And yet, diamonds are cut and polished. How is this possible? Describe the procedure and materials used.

[How Diamonds Work](#)

This How Stuff Works webpage explains the origins of diamonds, their properties, and provides links to several other websites that are concerned with diamonds.

[Diamonds Shape the World](#)

This American Museum of Natural History website discusses the

industrial applications of diamonds, their mining, and the machinery/tools in which they are used.

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UNIT 2: STRUCTURE AND PROPERTIES

Chapter 4: Chemical Bonding

Section 4.1 General Links

[Kekule's Structural Formulae](#)

This is the third page of an article explaining Kekule's contribution to developing a system of notation for chemical structures. The article indicates using his own drawings that what we call Kekule structures were in fact developed by another scientist named Couper.

p. 233
Practice
Question 7

Research and write a brief report outlining the basic principles of molecular orbital theory.

[Valence Bond Theory and Hybrid Atomic Orbitals](#)

This University of Waterloo website provides an excellent tutorial in valence bond theory, and then teaches how to apply this knowledge to deducing how hybrid atomic orbitals must work. This site includes images and self-assessment questions.

p. 240
Practice
Question 30

Information about atoms and molecules is often obtained from the interaction of substances with various forms of electromagnetic radiation. (Recall the bright-line and dark-line spectra of atoms.) For molecular substances, the infrared region of the electromagnetic spectrum is particularly useful for obtaining information about covalent bonds. Research and write a brief report answering the following questions.

- a. What characteristic of the atoms in a molecule is related to infrared (IR) radiation?**
- b. How are different covalent bonds distinguished in an IR spectrum? Why is the analysis useful in**

studying and identifying molecules?
c. Other than research chemists, who uses this technique?

[Basic Infrared Spectroscopy](#)

As part of a group of websites, entitled, "Organic Chemistry Online," this website provides an introduction to using IR Spectroscopy to identify organic molecules. Also provided are several sample IR spectrums, along with their analyses.

[Top](#)

Section 4.2 Case Study (Benzene)

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[The Benzene Ring](#)

This interesting website from the Chemistry Department of the University of Newcastle upon Tyne (in the U.K.) is full of images of benzene that several scientists proposed might represent the actual structure of the aromatic ring. It explains the advantages and disadvantages of many of the proposed models.

[Benzene](#)

This website was put together by a teacher to discuss the structures that are used to describe benzene, and to talk about benzene's actual structure. It incorporates atomic and molecular bonding theory into the explanation.

[Vibrational Modes of Benzene](#)

This chemistry website from the University of California, Berkeley contains 3 short animations that demonstrate the different molecule vibrations that can be used to account for benzene's composition and reactivity.

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Section 4.2 General Links

[Atomic Orbital Viewer](#)

This website contains an overview of atomic orbitals with many images to show representations of their shapes. More importantly, it also has downloadable software, entitled "Orbital Viewer," which allows you to generate pictures of atomic orbitals, with many different features included.

[Atoms and Molecules](#)

This McMaster University website has been prepared by the leading researcher Richard F.W. Bader, who discusses throughout a very organized group of websites, theoretical aspects of atoms

and their bonding.

[Ode to Hybridized Electron Orbitals](#)

A poem by Eric Tulsky.

[The sp, sp² and sp³ Hybrid Orbitals](#)

This Purdue University website has pictures of some hybrid orbitals, but also contains links to explanations regarding bonding theory and molecular/atomic orbitals.

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Practice

Question 6

Locate two or more VSEPR Web sites and compare them. Which do you prefer? List two or more criteria for evaluating the sites and indicate how each site did based on each criterion.

[What is VSEPR?](#)

This Purdue University website systematically explains in a variety of ways how exactly VSEPR theory works. It also provides several examples of molecules' shapes along with their images.

[Valence Shell Electron Pair Repulsion \(VSEPR\)](#)

This site is provided by a Chemistry professor at the University of Sheffield in England. It contains an explanation regarding the bonding of atoms, and proceeds to demonstrate the structures of several different atoms. You will need to download free CHIME software in order to access all of the information on this website.

[The VSEPR Theory of Molecular Geometry](#)

This website belongs to a group of websites, called "ChemTeam," that contain tutorials for high school chemistry students. This website contains a very organized explanation of VSEPR theory with several images.

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Practice

Question 7

Enzymes make up the largest and most highly specialized class of protein molecules. Describe briefly how their three-dimensional structure influences their function. How does the "lock-and-key" analogy relate to molecular shapes and the highly specific nature of enzyme reactions?

[Thousands of Locks and Keys](#)

This website connects molecular structure with the physiological function of certain molecules, like enzymes. It contains several images of molecules, and discusses their diverse roles in the human body.

[Enzymes](#)

This Industry Canada website is part of a "Genetic Engineering

Basics" group of sites. It provides an excellent article explaining very clearly and accurately what exactly enzymes are, along with what they do.

p. 247
Practice
Question 8

What are optical isomers? Describe the role that molecular shape plays in classifying optical isomers.

[Geometric and Optical Isomers](#)

As part of a set of websites entitled, "An Introduction to Chemistry," this website explains, using text and images, two different types of isomers: geometric isomers and optical isomers. It also provides a few examples of each type of isomer.

p. 250
Explore an Issue

Take a Stand: Linus Pauling and the Vitamin C Controversy

e. The vitamin C controversy is not the first time a famous scientist has made a claim that is disputed by most of the scientific community. What are the repercussions for a scientist who goes against the rest of the scientific community? Who usually "wins"? Is the practice and work of science completely objective?

[Linus Pauling lectures on Vitamin C](#)

This website article is a government official's report of a 92-year-old Linus Pauling's speech at a seminar on heart disease. It reports on his lecture on the connection between Vitamin C and cardiovascular disease.

[Vitamin C](#)

This informative website comes from the Linus Pauling Institute at Oregon State University. It discusses in good detail various aspects of the molecule, Vitamin C, including its function, the results of its deficiency, and some of its benefits in the human body.

[The Vitamin C Foundation](#)

This foundation's website serves as a platform for promoting the use and benefit of Vitamin C by sharing news and journal items that demonstrate Vitamin C's efficacy in a variety of health matters. The site contains several pro-Vitamin C links.

[The Vitamin C Controversy](#)

This article is found on a website belonging to the Life Extension Foundation, whose members have conducted large scale blood screening tests to determine the truth about dietary supplements.

This article describes a study showing that high doses of Vitamin C contribute to lower risk of cardiovascular death.

[The Dark Side of Linus Pauling's Legacy](#)

Written by Stephen Barrett, M.D., this article argues that Linus Pauling is responsible for spreading mis-information about Vitamin C, especially with respect to the common cold. The article argues that all large-scale clinical trials have not found any connection between the mega-doses of Vitamin C that Pauling recommended and any health benefit.

[Vitamin C: How Much Do You Really Need?](#)

This article, from a popular health and medical website for the public, explores the different studies that have recently shed light on the role of Vitamin C in good health. It shares the findings of several recent studies that have not succeeded in confirming Pauling's recommendations about Vitamin C.

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Section 4.3 Questions

p. 250

Question 5 Search the Internet for information on the current workplace and position of Dr. Ronald Gillespie, the co-creator of VSPER theory. What degrees does he hold? What are some of the major awards he has won? What is his major topic of research?

[Ronald Gillespie: A Lifetime in Chemistry](#)

This article, from the McMaster Chemical Extracts, explains Ronald Gillespie's role in developing VSEPR theory--a theory that predicts the geometric shape of molecules.

[Ronald J. Gillespie: Professor Emeritus](#)

This page is Dr. Gillespie's entry in the faculty pages of McMaster University. In it, Dr. Gillespie describes his research in Molecular Geometry. The page also contains links to his C.V. and a list of his numerous publications.

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Section 4.3 Questions

p. 250

Question 6

Some scientists argue that taste has developed as a protective mechanism. Many poisonous molecules taste bitter and ones that are useful to us have a more pleasant, often, sweet taste.

Write a brief summary about the relation of taste to molecular structure.

[Tasting the Shape of Molecules](#)

This page explains the connection between the shape/type of a molecule, and the way our body's tongue uses that shape to identify what the molecule might be. For instance, it describes how tasting can distinguish between bitter poisons and sweet, nutritious food.

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Section 4.3 General Links

[Molecular Models](#)

This site provides all common molecular shapes (shown with and without electron pairs) as interactive Chime models. The site is provided by the Chemistry Department at Okanagan University College.

[The Molecule of the Month](#)

Using this website, provided by the Virtual Library group of sites, you can get the molecular structure of several molecules in many different formats plus some neat stories about the molecule's discovery.

p. 264
Practice
Question 15

Wetting agents are very important in agriculture and other industries. What are wetting agents? Where are they used and for what purposes? Briefly explain how the function of wetting agents relates to the principles of intermolecular forces.

[Class A Foam for Fire Control](#)

This excellent article comes from Fire Magazine in Australia. It's very thorough discussion of the history of water and its fire-fighting capabilities leads steadily towards the present day, in which Class A foam is used to fight fires.

[New Surfactants for New Applications](#)

This report discusses the key property of surfactant--an ability to reduce the surface tension of water and other solvents--and explains how this property is used in a wide variety of practical applications. The website actually exists to promote a very detailed report on surfactants that the company has available for sale.

[Surfactants](#)

This company's website has for sale several chemical surfactants

with a variety of compositions and applications.

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Practice

Question 17

In 1966, Soviet scientists claimed to have discovered a new form of water, called polywater. The story of polywater is an interesting example of how people, including scientists, want to believe in a new, exciting discovery, even if the evidence is incomplete. Write a brief report about polywater, including how it is supposedly formed, some of its claimed properties, the explanation in terms of intermolecular forces, and the final evaluation of the evidence (specifically, the flaws).

[Polywater and the Role of Skepticism](#)

This excerpt from a report of the National Research Council briefly explains the emergence of knowledge about polywater, and then the resultant announcement that in fact polywater did not exist.

[Declustered Water, Anomalous Water and Crystals](#)

This site belongs to a group of sites by Mark Chaplin, entitled, "Water Structure and Behaviour." This site discusses all of the different forms of water that are purported to exist, including polywater, and simply explains what kinds of research have been performed on them, and the results that have been attained.

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Section 4.5 Questions

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Question 11

Some vitamins are water-soluble (e.g., B series and C), while some are fat soluble (e.g., A, D, E, and K).

- a. What can you infer about the polarity of these chemicals?**
- b. Find and draw the structure of at least one of the water-soluble and one of the fat-soluble vitamins.**
- c. When taking vitamins naturally or as supplements, what dietary requirements are necessary to make sure that the vitamins are used by the body?**
- d. More of a vitamin is not necessarily better. Why can you take a large quantity of vitamin C with no harm (other than the cost), but an excess of vitamin E can be dangerous?**

[Vitamin](#)

Wikipedia, the free encyclopedia, is this source of information on vitamins. Vitamins are broken up into fat-soluble and water-soluble groups. Click on the name of a vitamin to find out further information on that vitamin, including its chemical structure.

[Vitamin Deficiencies](#)

This family resource website provides an easy-to-read table describing all of the body's essential vitamins, and the disorders that might result from their deficiencies.

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Section 4.5 Questions

p. 266

Question 12

Many of the new materials that are being invented for specific purposes show an understanding of structure and bonding. One candidate that has been suggested as a future product is commonly known as the “fuzzyball,” C₆₀F₆₀ (s). What is the structure of this molecule? What use is proposed for this substance? Explain this use in terms of intermolecular forces.

[Fullerenes Foment a Feeding Frenzy](#)

This brief essay explores the history of the buckminsterfullerene molecule, and the understandings of the carbon atom and carbon-containing molecules that led up to it. It provides pictures of several carbon molecules as well.

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Section 4.5 Questions

p. 267

Question 13

People who wear contact lenses know that there are hard and soft contact lenses. The polymers used in each type of lens are specifically chosen for their properties. What is the property that largely determines whether the lens is a hard or soft lens? Write a brief explanation using your knowledge of intermolecular forces.

[Contact Lens Polymers](#)

This website from the State University of New York (SUNY) at Buffalo provides "a technical overview of the development, manufacturing, and future of contact lenses." It is written very clearly, it incorporates many images, and even relates the

properties of contact lens to their chemical composition.

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Section 4.6 Questions

p. 267

Question 14

Plastic cling wrap is widely used in our society. Why does it cling well to smooth glass and ceramics, but not to metals? Describe the controversial and social issue associated with use of this plastic wrap. How are intermolecular forces involved in starting the process that leads to this controversy?

[Safety of Plastic Food Wraps and Containers](#)

This site, sponsored by the American Plastics Council, provides an excellent overview of the issues regarding plastic wrap. It contains a broad set of links to various other websites and articles that put forth various arguments for and against plastic wrap.

[Plasticisers in Cling Film](#)

This website from a British university first explains the role of plasticisers in making cling wrap "cling," and then proceeds to describe an experiment that can be performed to extract the plasticiser from the wrap. This sort of experiment can demonstrate why it might be a good idea to avoid using some cling wraps with oily foods.

[New Studies on Plastic Wrap and Cheese](#)

This 1999 article from the New York Times describes the possibility that some food wraps contain endocrine disruptors--chemicals that might disrupt the body's hormonal balance.

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Practice

Question 10

Nitinol is known as the “metal with a memory.” It is named after the alloy and place where it was accidentally discovered: “Nickel titanium naval ordinance laboratory.” This discovery has revolutionized manufacturing and medicine in the form of many products that can “sense” and respond to changes. Research and write a brief report about Nitinol including its composition, a brief description of how it works, and some existing or proposed technological applications.

[Nitinol Technology](#)

This industry website discusses the two properties of nitinol, "shape memory" and "superelasticity," that make nitinol an extremely useful compound.

p. 274

The synthetic material moissanite (silicon carbide) looks like diamond and is used to simulate diamonds in jewellery.

- a. Compare the physical properties of moissanite and diamond.**
- b. Do these properties suggest a method to distinguish between a real diamond and a simulated diamond like moissanite? Explain.**
- c. What test do jewellers use to distinguish between these materials? Describe the principle used and the distinction made.**

[How Moissanite Jewels Work](#)

This set of websites from "How Stuff Works" explains the history of moissanite jewels, and provides a comparison of the qualities of moissanite, as compared with other gems. Finally, it describes the process of preparing a moissanite gemstone.

[The Mineral Moissanite](#)

This "Mineral Gallery" website provides a very useful and instructive look at moissanite. It discusses its history in quite a bit of details, and follows with a description of many of the mineral's properties.

p. 275
Practice Careers

Choose a university and use its Web site to obtain biographical information on one of its research scientists who is involved in research of intermolecular structures. Report on the scientist's training and education qualifications, and briefly summarize the nature of his/her current research project.

[Ontario Public University Addresses and Websites](#)

This Ministry of Education website lists all Ontario universities along with their contact information.

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Section 4.6 Questions

p. 276
Question 11

Clays and ceramics are substances closely related to silica, SiO₂(s). List some properties of clay and ceramics. How does the structure and bonding change when clay is fired (strongly heated) to produce a ceramic?

[A Brief Primer on Clay](#)

This website explains where clay comes from, how it is fired into different shapes, and provides an extreme close-up photograph of clay.

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Section 4.6 Questions

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Question 12

Research and report on the properties, applications, structure, and bonding in boron nitride BN(s).

[Boron Nitride \(BN\) Powders for Use in Research and Industry](#)

This corporate website explains the key properties of BN powder, and images of the compound from afar and up close.

[Top](#)

Question 13.

Experts agree that we are reaching the physical limit of how many transistors can be put onto a computer chip of a given size. Some scientists are already looking at a new generation of biological computers. Research one proposed biological computer. Describe some similarities and differences between this proposed computer and present computers. What are some of the promises of this new technology?

[Biological Computer Born](#)

This BBC News website discusses a new biological computer, affectionately called a "leech-ulator," that uses neurons from leeches to perform its computations. It is hoped that such biological computers might one day be able to compute data with only partial information, unlike today's computers.

[The Biological Computer](#)

This article discusses biological computers that might be the size of cellular components. Israeli researchers have been working on such a computer, the idea for which is based on the Turing machine of the 1930s.

[Computing Device to Serve as Basis for Biological Computer](#)

This article from ScienceDaily.com discusses a mechanical computer that has been built, and which will serve as a prototype for a biological computer that will be built using a ribosome to replace the computer.

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Chapter 4 review

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Question 27

**What material is used in the outer skin of a stealth bomber?
Describe how the structure and properties of this material
relate to its function.**

[B-2 Spirit Information](#)

You can access information on this site first by clicking in the Navigation menu on the left-hand side of the screen--select "Structure & Systems." You can then explore the site in a similar manner by choosing different options from the drop-down menu.

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UNIT 3: ENERGY CHANGES AND RATES OF REACTION

Chapter 5 – Thermochemistry

Practice

p. 300

Question 7

The energy content of foods is sometimes describes as “calories” rather than the SI unit of joules. Physical activity is describe as “burning calories.” Research the answers to the following questions:

- What are the relationships among a calorie, a Calorie, and a joule?
- Are calories actually burned? Why is this terminology used?
- What laboratory methods are used to determine the energy content of foods?

[Dietary Calorie versus "Physics" Calorie](#)

This Physlink.com site answers a question regarding the difference between dietary and physical calories.

[Fat Calories versus Protein/Carbohydrate Calories](#)

This American Council on Science and Health website contains an article from the Council's e-journal, Priorities. In this article, a medical doctor explains why sometimes calorie-counting may not help predict weight-loss or gain.

[Counting Calories](#)

This archived editorial from Foodproductdesign.com discusses several drawbacks to the conventional methods used to count calories, and tackles issues raised by such "supplement" foods as Olestra.

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Section 5.1 Questions

p. 305

Question 7

The bomb calorimeter is a commonly used laboratory apparatus. Research and write a brief report describing the applications of this technology.

[Use of the Bomb Calorimeter](#)

This website from Oregon State University's Chemistry Department contains a picture and audio link that explain the use of a bomb calorimeter in a lab.

[Heats of Combustion of Liquid Hydrocarbon Fuels](#)

This website of the White Sands Test Facility explains the process through which one might determine the heat of combustion of hydrocarbons. It contains many links to other NASA-affiliated websites.

[Thermochemistry](#)

This site belongs to a group of private Web sites hosted by Erik Epp, called Erik's Chemistry. It provides an excellent and succinct overview of thermodynamics at a first-year university level.

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Question 8

Hot packs and cold packs use chemical reactions to produce or absorb energy. Write a brief report describing the chemical systems used in these products and their usefulness.

[Hot and Cold Reactions](#)

Using basic principles to begin with, this Dartmouth University website explains how exactly it is possible that systems may increase or decrease in temperature independent of their surroundings.

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Sections 5.2 Questions

p. 312

Question 7

The propane refrigerator seems to be a contradiction in terms: the exothermic combustion of a hydrocarbon is used to cool food.

- a. Find out how this device functions and what changes in matter occur in its operation.**
- b. Calculate enthalpy changes expected in a typical example.**

[How Refrigerators Work](#)

This How Stuff Works website explains the functioning of refrigerators. If you turn to page 5 in the article, you will find an explanation of gas and propane refrigerators, along with a link to a much more detailed website.

[The Invention of Freon](#)

This article from About.com explains how Midgely and Kettering invented Freon for General Motors. It also goes on to discuss their other inventions--lead gasoline and the automobile ignition system.

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Practice

p. 344
Question 2

Nuclear reactors in the United States and Europe use different systems than the CANDU system. Research and make a chart to summarize the similarities and differences among these systems.

[The Virtual Nuclear Tourist](#)

This website contains links to an astounding amount of information regarding the world's nuclear power plants.

[Safety of Nuclear Power Reactors](#)

This briefing paper from the Uranium Information Centre of Melbourne, Australia discusses several safety issues regarding nuclear power reactors.

[The Reactor Engineer's Home Page](#)

This site simply lists a large number of links that are divided into categories like "Professional Organizations," "International Nuclear Agencies," and other useful titles.

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Practice

p. 346
Question 4

Current nuclear power generation uses nuclear fission reactions. Why are fission reactions used instead of fusion reactions? Report on what progress has been made in making nuclear fusion practical as an energy source.

[Fusion Power](#)

This article from the BBC News website addresses the potential attainment of fusion power by leading scientists in the United Kingdom.

[A Galaxy of Fusion Reactors](#)

This picture of a galaxy is found on the Princeton Plasma Physics Laboratory website, a laboratory that is devoted to making fusion power a reality.

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Section 5.6 Questions

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Question 2

Research and report on atomic energy in Ontario. Include descriptions of:

- a. locations of nuclear facilities;**
- b. amount of power generated; and**
- c. advantages and disadvantages of this energy source.**

[Ontario Power Generation: Nuclear Power](#)

In this Operations website of Ontario Power Generation, the nuclear power that is used to meet "almost half of the province's electricity needs" is discussed. The site also contains links to power production maps, and information about hydroelectric power, with several additional links on other topics.

[Directory of the Canadian Coalition for Nuclear Responsibility](#)

This directory of websites contains links to over a hundred different documents, from reports and policy documents to the results of research papers and consumer opinion information--all having to do with dangers and required precautions regarding nuclear reactors.

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Question 3

Coal is often described as the “dirtiest” fossil fuel used for power generation. Name other fossil fuels that can be burned to generate power and write a short report discussing their advantages and disadvantages, or list the advantages and disadvantages in a table.

[The Hidden Cost of Fossil Fuels](#)

An appeal from the American Union of Concerned Scientists, this briefing document addresses the hidden "costs" of fossil fuels: namely, the environmental damage that manifests itself from long term fossil fuel usage in water, land and air pollution.

[Natural Gas](#)

From the International Council for Local

Environmental Initiatives, this website reprints an article of the Energy Educators of Ontario about natural gas. It explores the gas's origins, usage, and environmental impact.

[The Environmental Impact of Natural Gas](#)

This site promotes natural gas on behalf of several organizations, by addressing the environmental impact of other fuels that might be alleviated, especially with regard to air pollution.

[Waste-to-Energy](#)

This website describes the waste-to-energy process, and explains how exactly garbage can be used to power homes and industry through the process of combustion.

[Future Fossil Fuels](#)

This website belongs to the Department of Energy's Fossil Energy group of sites. Being an educational site, it provides lots of instructive material, clearly marked as being geared towards younger or older students.

[Ontario Power Generation: Fossil](#)

This Operations website of the Ontario Power Generation describes how fossil fuels are used to provide for much of Ontario's required electricity.

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Question 4

Both geothermal and solar energy have been suggested as clean and efficient alternatives to fossil fuels and atomic energy. Research and write a brief report on the practicality of one of these energy sources.

[Concentrating Solar Power Technology](#)

This website is hosted by Solarpaces.com, an international organization that is committed to increasing the commercial use of solar power technology. This webpage explains the various technologies that are in use to collect and concentrate solar radiation, and to convert it into useable energy.

[Solar Energy Topics](#)

Hosted by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, this website discusses, and contains links to further information about several solar power technologies and issues.

[Geothermal Energy Program](#)

Hosted by the U.S. Department of Energy's Energy Efficiency and Renewable Energy Network, this website contains links to information about geothermal energy in general, along with links to information about their program and other web resources that are available.

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Question 5

Hydrogen power is described by some as the ideal alternative to fossil fuel combustion because the only product is water. Others argue that “dirty” energy source are used to produce hydrogen fuel, so that the pollution is just produced somewhere else. Find out how hydrogen fuel is obtained and report on the advantages and disadvantages of this alternative energy source.

[Power Systems Software Development](#)

This combustion research facility works with support from the U.S. Department of Energy's Hydrogen Program. This site describes a conceptual power park, and contains links to information about other research projects and topics.

[Zero Emission: Coal to Hydrogen](#)

Hosted by the Los Alamos National Laboratory of the University of California, this website describes strategies that are used to reduce toxic emissions from the combustion of fossil fuels. One strategy discussed in detail is that of using carbon dioxide to carbonate minerals, mimicking a process that occurs in nature.

[Hydrogen... The Freedom Fuel](#)

This website provided by the National Hydrogen Association (NHA), promotes the use of hydrogen in fuel cells, as a safer alternative to existing fuels. It contains several links, some multimedia, to further information about hydrogen.

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Section 5.6 Questions

Question 6

Every year several groups in Ontario organize for Canadian families to host children from the Chernobyl area of Ukraine. Research and report of the effects of the Chernobyl nuclear disaster, and how these Ontario communities are trying to improve life for a few survivors of the Chernobyl disaster.

[Chernobyl Radiation Disaster Information](#)

This website provides an "independent resource and information about radiation disaster." It contains several links to study pages and resource materials about Chernobyl and other radiation disasters.

[Chernobyl: Ten Years on Radiological and Health Impact](#)

Provided by the Nuclear Energy Agency, this website contains an assessment that a committee has made on the long-term impact of the Chernobyl disaster. It is quite details, and contains some useful resource links, like a glossary of terms used in the report.

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Chapter 5 Review

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Question 19

Canadians use more energy per capita than almost any other country in the world.

- a. List some factors that contribute to this level of consumption.**
- b. Compare Canada's energy consumption with that of another country. At the same time, compare the factors listed in a.**
- c. Choose one source of energy used in Canada, and research the efficiency and environmental impact of our use of this type of energy.**
- d. Write a short opinion piece on whether it is morally appropriate for Canada to have the present level of energy consumption.**

[Canada Analysis Brief](#)

The Energy Information Administration (EIA) gathers official energy statistics for the U.S. Government. This website contains its report on Canada in terms of energy production, use, and export.

[Canada: Data and Forecasts](#)

The U.S. Department of Energy's E.I.A. herein provides links to important data about Canada's energy status, as well as forecasts of Canada's future in terms of energy.

[Lower Energy Consumption](#)

National Research Council Canada hosts this web page as part of its "Design for Environment Guide." This site explains why a strategy of reducing consumption is endorsed, and contains links to other parts of the guide that explain Canada and energy in terms of the "overall picture."

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UNIT 3: ENERGY CHANGES AND RATES OF REACTION

Unit 3 – Performance Task and Review

p. 417

Question 28

The concept of half-lives can be applied to biological, as well as chemical, systems. There is some concern that antibiotics, fed to livestock to speed their growth by killing disease organisms, are excreted in the animals' urine, thereby contaminating ground water. This rate of excretion appears to be a first-order reaction. Research this issue, and find out how long animals keep 50% of the administered antibiotics in their bodies.

[Book Review: "The Rise and Fall of Modern Medicine"](#)

In this book review, Jeffrey Shallit discusses and contests Le Fann's position in his book. There is an interesting question raised about antibiotics--why did organisms start making them?

[Purdue Agriculture - Impact](#)

This Purdue University website explains an alternative that researchers have come up for a certain class of antibiotics that are currently in widespread use with cattle and livestock across the United States.

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Question 29

Papain is an enzyme derived from tropical papaya fruit. It acts as a catalyst to break down the peptide bonds in proteins. Research to find how this enzyme is being marketed for consumer use, and comment on the potential effectiveness of these uses.

[The Fruits of Genetic Modification](#)

This website, of McGill University's Office for Chemistry and Society, discusses the chemical papain, that has been synthesized from the papaya fruit. It goes on to describe the genetic modifications that have been made to papaya to allow it to resist

the danger of certain viruses.

[Papaya - pawpaw](#)

This website begins by describing the human history of papaya, and then goes into an explanation regarding the chemistry of the papaya fruit. Of course, it mentions papain, and its widespread use as a meat tenderizer.

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Unit 3 Review

General Links

[Energy Technology and Fuel Economy](#)

This government website addresses fuel economy, an area that can be significantly improved upon, given that currently less than 15% of the energy expended by a car is all that is used to make it move forward.

[Thermographic Surveys](#)

This corporate website promotes a thermographic surveying technique that allows for temperature detection without any contact.

[Snell Infrared](#)

This corporate website promotes the company's infrared detection services. They provide thermograms as a service for a variety of different purposes, from detecting flaws in new computer chips, to identifying swollen muscles in the body.

[EPA's Global Warming Site](#)

This website of the United States Environmental Protection Agency provides information about global warming, with sections on climate, emissions, impacts, and actions.

[Global Warming: Early Warning Signs](#)

This website contains information about changes that have been recorded around the world, related to the phenomenon of global warming.

[Fusion Energy](#)

This website briefly explains, in simple language with diagrams, nuclear fusion and fission.

[Introduction to Fusion](#)

Iter Canada is a non-profit organization that promotes nuclear energy as an alternative source of power. In this site you will find a straightforward argument in favour of fusion energy.

[Explosives](#)

This Encarta.msn.com article covers explosives, their

characteristics, their different types and their safety.

[Explosives Science](#)

This article written by two Los Alamos researchers explains in great detail how explosives work. The article includes several pictures and diagrams, along with many references.

[Homogeneous Catalysis](#)

This corporate website explains the process of homogeneous catalysis, along with the company's techniques for using molecular mechanics and quantum mechanics to determine the catalytic results that are being sought after.

[The Growing Roles of Expansins](#)

This article from the science journal, "The Proceedings of the National Academy of Sciences," discusses plant molecules called expansins, and their structure and function.

[Plant Growth Regulators](#)

This website contains notes from a university lecture on the effects of hormones on plant growth. It discusses the many classes of hormones one by one, and addresses each one's likely function and effect on growth.

[Ripening Tomatoes with Ethylene](#)

This article from the University of Florida discusses the use of ethylene, a natural plant hormone, to ripen tomatoes and other fruits. It includes information on initiating ripening, ideal conditions, and a few diagrams that summarize the process in a commercial setting.

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UNIT 3: ENERGY CHANGES AND RATES OF REACTION

Chapter 6 – Chemical Kinetics

Practice

p. 371
Question 7

Many boxed, dry cereals contain BHT (butylated hydroxytoluene, also named 2, 6-di-tert-butyl-p-cresol) in the packaging material. Use the Internet or other resources to discover and report on the effect of BHT on reaction rates.

[What are BHA and BHT?](#)

This About.com website contains a very comprehensive resource for information about BHA and BHT, with everything from molecular structures, to links to other websites with further information.

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Section 6.2 Questions

p. 371
Question 4

Heterogeneous catalysts are generally preferred in industrial reactions. Explain why this is so, with reference to several industrial examples not mentioned in the text.

[Catalysts for Change](#)

The Royal Society of Chemistry sponsors a group of web pages called the "Chemical Science Network." This web page contains an article about work being done by researchers on designing a certain type of catalyst that will create chiral-specific drugs, among other things.

p. 371
Question 5

How do catalytic converters work? Research and write a brief report on the materials and design of these devices.

[How Catalytic Converters Work](#)

This How Stuff Works Web site contains a five-page article on catalytic converters, including their role in reducing pollution, along with a mention of alternative means of reducing pollution. A useful list of additional web resources is also provided.

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Section 6.3 Questions

p. 382

Question 7

Radiocarbon dating is a common way of determining the age of archaeological specimens, but the carbon-14 isotope is only one of a number of radioisotopes used. Research and report on the applications of carbon-14 and other isotopes to such dating techniques.

[How Carbon-14 Dating Works](#)

This How Stuff Works website contains a three-page article explaining how carbon-14 dating is used to determine the age of fossils. A page containing links to other web resources is also found at the end of the article.

p. 382

Question 8

Nuclear waste storage is a controversial issue. Research the Internet to answer the following questions:

- a. What kinds of nuclear wastes are produced by CANDU reactors, what are their half-lives, and what are the products of their radioactive decay?**
- b. Where are the wastes currently stored?**
- c. What are some of the proposed long-term solutions to the problem of nuclear waste?**
- d. Imagine that you are a member of a mining community. A local abandoned mine has been proposed as a site for storage of nuclear waste. Write a letter to your MP supporting or opposing the proposal. Back up your opinion with arguments based on specific information.**

[The Nuclear Tourist: Table of Contents](#)

This website abounds with information about nuclear power plants around the world--locations, pictures, research data, and much more.

[Nuclear Waste Management](#)

This "Canadian Nuclear FAQ" provides answers to questions about Canada's approach towards nuclear waste management. The information is quite detailed, and yet very easy to read.

[CANDU 6 Fuel](#)

This New Brunswick Power website explains the process that is undergone in order to get electricity from the CANDU Nuclear Power Plant.

[Canadian Coalition for Nuclear Responsibility](#)

The Canadian Coalition for Nuclear Responsibility (CCNR) is a non-profit organization that researches and teaches about nuclear energy. This page contains hundreds of links to resources from around the world that have to do with nuclear energy.

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Section 6.4 Questions

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Question 5

Ozone is a molecule that is helpful in the upper atmosphere but harmful at ground level. Research the Internet to answer the following questions:

- a. Why is ground-level ozone a problem?**
- b. What are the mechanisms of the reactions that lead to its production?**
- c. What is the connection between the production of ozone and kinetics?**

[Ground-level Ozone \(Smog\) Information](#)

This website of the U.S. Environmental Protection Agency provides air quality information for the New England region in the north-eastern United States. It provides many useful links to other resource websites.

[Reducing Smog](#)

This informative website is provided by the Environmental Protection Branch of Environment Canada. It explains what smog is, how it originates, and what we can do to reduce smog.

p. 391

Question 6

John Polanyi, a scientist at the University of Toronto, won the 1986 Nobel prize for his work in chemical kinetics. Imagine that you are a newspaper reported describing Polanyi's work in an article written the day after he received the prize. Include in your article a description of his area of research and

the experiments he performed.

[Polanyi for Youth](#)

This University of Toronto website is devoted to one of its most distinguished alumni, John Polanyi. It provides information about his life, the topics he studied, the Nobel prize, and much more.

[The Nobel Prize in Chemistry 1986](#)

This Nobel site provides information about the prize that Polanyi shared with two U.S. researchers, their biographies, and the lectures that they presented in 1986.

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Practice

p. 397

Question 6

“Platinum should be described as a precious metal, not because of its use in jewellery but because of its use as a catalyst. “ Do you agree or disagree with this statement? Back up your opinion with references to specific applications of platinum.

[Platinum - Applications](#)

Read about the different applications of platinum in the automotive, jewellery, chemistry, and petroleum industries.

[Platinum - Uses](#)

This Webelements.com website provides an exhaustive list of uses for platinum, an element that is used in things as diverse as pacemakers, cigarette lighters and therapeutic agents for cancer.

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Explore an Issue – Debate: Food Preservation

Methods of food preservation in different communities - traditional and modern techniques.

Which of these many ways of preserving food is best for our health? For our planet? For our wallets? For our community?

[Food Preservation Methods](#)

This university website describes government guidelines for various methods of food preservation, including canning, drying and freezing. It contains links to several websites for each of these, and other, methods for keeping food safely.

[Food Preservation Information and Documents](#)

This website belongs to the University of Wisconsin - Extension program, which provides many online educational resources. This page contains links to resources regarding canning, freezing, and pickling--all very important methods for food preservation.

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Practice Careers

p. 398

Question 8

Choose a career that interests you, either one of those featured or another that involves rates of reactions, and report on the following:

- (a) training required;**
- (b) working conditions; and**
- (c) current employment opportunities.**

[Chemistry Careers](#)

This Ball State University Department of Chemistry website provides a lengthy list of careers available to those that study chemistry in university.

[Careers](#)

This American Chemical Society website contains links to information about careers and salaries of chemists. To see how much chemists earn, follow the link entitled, "Career Services Publications," and look at the results of their most recent salary survey.

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Section 6.5 Questions

p. 400

Question 5

Enzymes have application in both body chemistry and industrial reactions. Write a brief report describing the function of an enzyme (not yet mentioned in this chapter) in the human body or in industry.

[Enzymes and Enzyme Activity](#)

This private website is managed by Ralph Logan. It explains enzymes and their relevance by first explaining proteins and catalysts.

[Enzymes: Classification, Structure, Mechanism](#)

This website from Washington State University explains how enzymes work, with easy-read text and diagrams.

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Activity 6.5.1 – Catalysts in Industry and Biochemical Systems

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Using the Internet, find at least 10 examples of enzymes and industrial catalysts.

- a. For each of the enzymes or catalysts, record the reaction that is catalyzed; how the catalyst was discovered; where and how the catalyst or enzyme acts for an enzyme, physiological implications of its presence or deficiency, whether such a condition exists, and, if so, how it is currently treated for an industrial catalyst, economic implications of its use.**
- b. Which of the industrial catalysts has the greatest effect on you life? Explain.**
- c. Summarize your research.**

[Enzymes and Enzyme Activity](#)

This private website is managed by Ralph Logan. It explains enzymes and their relevance by first explaining proteins and catalysts.

[Enzymes: Classification, Structure, Mechanism](#)

This website from Washington State University explains how enzymes work, with easy-read text and diagrams.

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UNIT 4: CHEMICAL SYSTEMS AND EQUILIBRIUM

Chapter 7 – Chemical Systems and Equilibrium

Section 7.1 Questions

p. 438

Question 11

Many of the nutrients in digested food, such as the carbohydrate fructose, are absorbed into the cells of the small intestine by diffusion. This occurs because, after a meal rich in carbohydrates, the concentration of fructose in solution in the intestinal tract is higher than the concentration inside the surrounding cells.

- (a) Will diffusion result of the absorption of all fructose molecules from the digesting food travelling through the intestine? Explain.**
- (b) Consult a general biology textbook or conduct Internet research to determine how cells ensure that they absorb the maximum possible amount of nutrients.**

[How Nutrients and Other Molecules Get into Cells](#)

This news article gives a general description of how cells absorb nutrients and molecules.

[Cellular Metabolism](#)

This page provides a good overview of basic cellular metabolism.

[Cellupedia](#)

This is another page that explains cellular processes.

[Top](#)

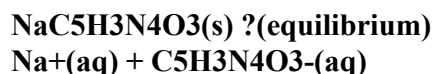
Practice

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Question 8

The digestion of some high-protein foods, such as red meat,

beans, lentils, and shell-fish, releases uric acid, $\text{HC}_5\text{H}_3\text{N}_4\text{O}_3(\text{aq})$, which ionizes into hydrogen ions, $\text{H}^+(\text{aq})$, and urate ions, $\text{C}_5\text{H}_3\text{N}_4\text{O}_3^-(\text{aq})$, in the bloodstream. People whose kidneys do not function properly cannot excrete urate in the blood. This sometimes leads to a painful form of arthritis known as gout, characterized by the formation of tiny needle-like crystals of sodium urate, $\text{NaC}_5\text{H}_3\text{N}_4\text{O}_3(\text{s})$, in joints and tissues, according to the equation



- Suppose you were a nutritionist. What advice could you give to your patients who suffer from gout? Explain why following the advice would be effective.
- Many women take calcium supplements on a daily basis to prevent the loss of bone mass (a condition known as osteoporosis). If a woman suffering from osteoporosis has gout too, she may develop kidney stones (which can consist of calcium urate). Write a chemical equilibrium equation for this reaction and explain why this happens.
- Research and report on other non-dietary treatments of gout.

[Gout](#)

This web page, sponsored by the Arthritis Foundation, provides detailed information about gout, its symptoms, causes, and treatment options.

[Gout Center](#)

This site provides information about gout, its symptoms, its causes, and specific drugs that are used in its treatment.

[Gout and Pseudogout](#)

This page from MEDLINEplus lists a number of links about gout, its diagnosis, prevention, and treatment.

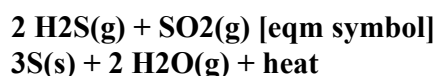
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Section 7.3 Questions

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Question 9

Hydrogen sulfide is a foul-smelling and toxic byproduct of the processing of crude oil and natural gas. One method to recover H_2S so that it does not contaminate the environment is known as the Claus process, which involves the following reaction:



The Claus process is capable of removing up to 95% of the sulfur emissions from petroleum-processing plants.

- a. Research and report on the Claus process.**
- b. Describe why it is advantageous to remove the sulfur from the process as quickly as it forms.**

[Exploring the Claus Process](#)

This page provides simplified flow diagrams of the typical Claus process, for removing sulfur emissions from petroleum-processing plants, as well as a summary of the chemistry involved.

[Converting Hydrogen Sulfide by the Claus Process](#)

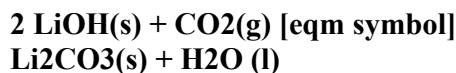
This page provides simplified flow diagrams of the typical Claus process, for removing sulfur emissions from petroleum-processing plants, as well as a summary of the chemistry involved.

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Section 7.1 Questions

p. 460

Question 10 An air purification system involving lithium hydroxide, LiOH, was used in NASA's Apollo missions to the moon. LiOH absorbs carbon dioxide.



Use Le Chatelier's principle to explain why the amount of time astronauts can spend in a spacecraft is limited.

[MSDS Data Sheet](#)

Try to pick out useful information from this Material Safety Data Sheet.

[Le Chatelier's Principle](#)

This page summarizes Le Chatelier's Principle.

[How to Walk, Talk, and Breathe on Mars](#)

This document discusses design specifications for a proposed space suit for the exploration of Mars. A discussion of the carbon dioxide scrubbing unit containing lithium hydroxide is included.

p. 460

Question 11

When the Olympic Games were held in Mexico in 1968, many athletes arrived early to train in the higher altitude (2.3 km

above sea level) and lower atmospheric pressure of Mexico City. Exertion at high altitudes, for people who are not acclimatized, may make them “lightheaded” from lack of oxygen. A similar effect occurred at the 2002 Winter Olympics in Salt Lake City, Utah (1.3 km above sea level). Use the theory of dynamic equilibrium to explain this observation. How are people who normally live at high altitudes physiologically adapted to their reduced-pressure environment?

[International Altitude-Training Symposium](#)

This page provides background to the effects on altitude on training, the benefits of high altitude training, and suggestions for how to train at high altitudes.

[Altitude Illness](#)

This page describes what happens to people when they move to higher altitudes, including the physiological changes that take place.

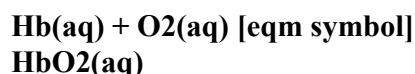
[Three High-Altitude Peoples, Three Adaptations to Thin Air](#)

This page describes how several groups have adapted to living at high altitudes.

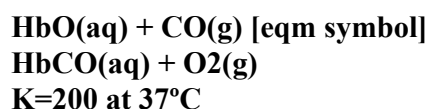
p. 460

Question 12

Hemoglobin, Hb, a protein molecule found in red blood cells, attracts and binds inhaled oxygen, which can then be transported throughout the body.



Carbon monoxide, CO(g), binds more readily to hemoglobin than oxygen and can displace oxygen according to this equilibrium:



Consider this scenario:

A patient, unconscious due to suspected carbon monoxide poisoning, has just been brought to the hospital emergency ward where you are the doctor in charge. Based on your knowledge of Le Chatelier's principle, what treatment would you recommend?

[The Hidden Danger of Carbon Monoxide Poisoning](#)

This page describes the symptoms, medical consequences, causes, treatments and prevention suggestions of carbon monoxide poisoning.

[Carbon Monoxide and Physiological Effects](#)

This page gives a detailed explanation of how carbon monoxide

affects the body.

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Practice

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Question 5

- a. Ammonia, produced by the Haber process, can be oxidized to nitric acid, the raw material used in the manufacture of explosives. Perform library or Internet research to determine the most common types of explosives produced with nitric acid.
- b. Draw structural formulas for the three most common nitrogen-based explosives. What are the specific uses of each?
- c. Write the chemical equation that describes a nitroglycerine explosion. Why is this reaction explosive?
- d. What is gun cotton? What are its uses? How is it made?

[Nitric Acid General Information](#)

This page has a good deal of information regarding nitric acid.

[Nitric Acid](#)

This page provides general background information about high explosives. A chemical equation for the decomposition of nitroglycerine is given.

[Explosives](#)

This page provides an interesting graphic history of the development of explosives as well as a brief summary of how explosives can be detected.

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Section 7.4 questions

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Question 2

The Haber process requires nitrogen and hydrogen as reactants.

- (a) Suggest reasonable sources for each of these elements.
- (b) Conduct library and/or Internet research to learn how modern ammonia production facilities obtain pure hydrogen nitrogen for the process.

[Haber Process Research Site](#)

This page provides background into the history of the Haber

process, the raw materials it requires, the reaction conditions required, and the importance of nitric acid to the production of fertilizers.

[Production of Ammonia](#)

This site explains how ammonia is produced and how production of it is changing in the U.S.

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Question 3

To be used by growing plants, elemental nitrogen must first be converted into another form (such as ammonia) in a natural process called nitrogen fixation. The Haber process is synthetic nitrogen fixation.

- (a) How do bacteria fix nitrogen naturally?**
 - (b) Currently, which of the two processes, synthetic and natural, fixes the most nitrogen.**
 - (c) What problems have arisen from the dramatic increase in nitrogen fixation in the last century?**
- Pick one of these problems and suggest some remedies.**

[The Nitrogen Cycle and Nitrogen Fixation](#)

The site gives a thorough summary of the role of nitrogen in the biosphere, nitrogen fixation, nitrogen-fixing organisms, and the nitrogen cycle.

[Problems with Nitrogen Pollution](#)

This site offers a good summary of the problems associated with nitrogen pollution, the nitrogen cycle and how human activity has affected it.

[Fertilizer Consumption](#)

This page provides graphics showing the dramatic rise in worldwide fertilizer consumption.

[Role of Nitrogen in Plants](#)

This document gives in depth background to the efficient use of fertilizers. It covers the nitrogen cycle, soil chemistry, current practice in the use fertilizers, and the production of fertilizers.

[Nitrogen](#)

Here is a general description of nitrogen and its uses.

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Explore an Issue – Take a Stand: Can We Do Anything About Pollution?

p. 501

Proposition: The second law of thermodynamics makes

pollution an inevitable result of human activity. There's nothing we can do about it.

Conduct independent library or Internet research on both sides of the issue.

a. Prepare an individual position paper on the issue.

[Thermodynamics: The Second Law](#)

This site gives a graphic explanation of the second law of thermodynamics.

[The Second Law of Thermodynamics](#)

The document gives a thorough summary of the second law of thermodynamics, activation energy, and concludes with the link between the second law of thermodynamics and pollution.

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Chapter 7 review

p. 525

Question 21

The operation of a halogen lamp depends, in part, on the equilibrium system



Research the role of temperature in the operation of a halogen lamp. For example, how is it possible for a halogen lamp to operate with the filament at 2700°C when the tungsten would normally decompose/oxidize at this high temperature? Is such a high operating temperature desirable?

[How Do Halogen Lights Work?](#)

This page describes how halogen lamps work, how they differ from standard light bulbs, and why they are sometimes called “quartz halogen”. It also describes how the equilibrium given in question 21 prolongs the life of the lamp.

[The Halogen Cycle in an Incandescent Lamp](#)

This page provides very useful diagrams showing the operation of the tungsten iodide equilibrium in a lamp.

p. 525

Question 23

Explain how equilibrium principles are applied to optimize the industrial production of sulfuric acid.

[Sulfuric Acid](#)

This page, compiled from Chemical and Engineering News, June

25, 2001 provides a good summary of the chemistry of sulfuric acid, including its synthesis, environmental concerns and economic importance.

[Sulfuric Acid 2](#)

This page provides an explanation of the synthesis of sulfuric acid, along with some other interesting information.

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UNIT 4: CHEMICAL SYSTEMS AND EQUILIBRIUM

Unit 4– Performance Task and Review

p. 635
Analysis

d. Research to find the reaction mechanism and ratios of entities in EDTA's reaction with calcium.

k. What are some commercial and pharmaceutical uses for EDTA? Name three products you can purchase at a grocery store or pharmacy that contain EDTA and explain why EDTA is added to the product.

l. Is EDTA safe? Describe safety considerations associated with the use of EDTA as a laboratory reagent and as a consumable product.

[MSDS: EDTA Disodium Salt](#)

This page contains a Material Safety Data Sheet (MSDS) for the disodium salt of EDTA. This document is useful when considering the safe use of EDTA in the lab.

[Oral EDTA, Lead & More](#)

This site is a summary of the many pharmaceutical uses of EDTA.

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Unit 4 Review

p. 644
Question 56

Liquid carbon dioxide may soon replace the organic solvents currently being used in dry cleaning. Liquid carbon dioxide is just as effective in dissolving grease and far more environmentally friendly. To prevent liquid carbon dioxide from evaporating, the washing machines must be pressurized to a minimum of 517.6 kPa at 56.6°C.

(a) Use Le Chatelier's principle and the following equilibrium to explain why high pressure is required to keep carbon dioxide in the liquid state.

CO₂(g) [eqm. symbol] CO₂(l) + heat

(b) High levels of carbon dioxide can be dangerous.

What safety precautions should be observed in the building where the dry cleaning is done?

(c) Conduct library or Internet research to determine the advantages of using liquid carbon dioxide as a dry-cleaning solvent.

[Dry-Cleaning with Liquid Carbon Dioxide](#)

This site provides detailed information on the use of liquid carbon dioxide as a dry cleaning solvent, including how it works, its advantages, and its cost benefits.

[What is CO₂? An Ideal Solvent](#)

This site, operated by dry cleaning equipment manufacturer, also describes the benefits of liquid carbon dioxide as a dry cleaning solvent.

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UNIT 4: CHEMICAL SYSTEMS AND EQUILIBRIUM

Chapter 8 – Acid-Base Equilibrium

Practice

p. 546

Question 16

d. There is some research that suggest that women's diets may affect the likelihood of their getting pregnant, as sperm are sensitive to pH. Research this topic, and make some diet suggestions for a woman who is trying to get pregnant.

[Becoming Pregnant](#)

Practical advice is provided on how to maximize the chances of becoming pregnant.

[Pregnancy and Essential Fats](#)

The factors that can prevent pregnancy are listed.

[Can Acid Levels Kill Sperm](#)

This page describes how unusually low vaginal acidity can kill sperm.

[Infertility](#)

This site provides a good overall summary of the causes of infertility for men and women, methods of diagnosis, treatments, and coping strategies.

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Question 6

When food enters the stomach, it stimulates the production and secretion of hydrochloric acid for digestion, reducing the pH of the stomach contents from 4 to 2.

- Compare the $[H^+(aq)]$ before and after the change in pH.**
- Conduct library or Internet research to find out how the stomach protects itself from the corrosive effects of this low pH level.**

[How Does Your Stomach Keep From Digesting Itself](#)

The layers of the stomach and their function are described as well as detailed information of how the stomach protects itself from being digested.

[NSAIDS and Peptic Ulcers](#)

This page provides basic information on how the stomach protects itself from the digestive juices it secretes. Information about the formation of peptic ulcers is also provided. Medications used to treat disorders of the stomach lining are also mentioned.

[Stomach and Duodenal Ulcers](#)

This comprehensive page describes what ulcers are, their causes, symptoms and possible treatment.

[Ulcers - A Microbial Infection?](#)

This article describes *heliobacter pylori*, a bacterium responsible for stomach ulcers and how the bacterium is adapted to surviving the hostile environment of the stomach. Treatments to rid the stomach of this pest are also mentioned.

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Section 8.1 Questions

p. 550

Question 9

Conduct library or Internet research to obtain information to answer the following questions about gastroesophageal reflux disease, GERD.

- a. What is GERD?**
- b. Who is usually affected by this condition?**
- c. Describe the apparatus used to diagnose this condition.**
- d. What treatments are currently available for this disease? Include examples of chemotherapeutic and surgical interventions.**

[An Introduction to GERD](#)

This website contains an overview of GERD; animations of general acid reflux; parietal cell acid production (i.e., the cells in the stomach lining that produce acid); an animation of gastroesophageal reflux; symptoms and possible causes of GERD.

[GERD Online](#)

This site is an online information database for patients with GERD. It offers an overview of the disease, FAQ's, medical advice and a description of surgical procedures used to treat GERD.

[Understanding GERD](#)

This page, maintained by the American College of Gastroenterology, provides general information on heartburn and GERD, treatments for heartburn, and the complications that can arise from GERD.

p. 550

Question 10

Conduct library or Internet research to answer the following questions regarding acid-free paper.

- a. What is acid-free paper? Why is it called “acid-free”?**
- b. What are the primary uses of acid-free paper?**
- c. List advantages and disadvantages of its use.**

[Basic Facts About Paper Deterioration](#)

Background into paper deterioration and current techniques used to deacidify paper is provided.

[Chemistry of Aging](#)

This document is part of a larger text on the deterioration of materials as they age. Detailed information on the acid hydrolysis of paper is provided.

[Paper Decay](#)

This page provides a comprehensive summary of why acidic paper decays, how paper decay can be monitored, and methods currently in use to preserve acidic paper.

[Conservation of Library and Archival Materials](#)

This comprehensive document provides current information about paper decay, how acidic paper can be treated and paper storage concerns.

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Section 8.2 questions

p. 580

Question 21

Aniline, $\text{C}_6\text{H}_5\text{NH}_2$, is a colourful weak base closely related to ammonia, NH_3 .

- a. If the pH of a 0.10 mol/L aniline solution is 8.81, calculate the K_b for aniline.**
- b. Aniline has been used as a pigment for centuries. What colours are aniline dyes? How do the colours of aniline dyes vary with pH? Research and write a short report on aniline dyes.**

[Dyestuffs and Dyeing of Leather](#)

This page describes the basics of modern dyeing techniques. It also compares the chemistry of anionic, amphoteric, and cationic dyes (including aniline).

[Ruglore: Dyes](#)

This page compares natural and synthetic dyes and provides an overview of the history of dyes in rug manufacturing.

[Mauve: How One Man Invented a Colour That Changed the World](#)

This page also describes William Perkins' discovery of mauve and provides an interesting insight in Perkin, the inventor and entrepreneur.

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Question 22

The stomach wall has a protective mucous lining that prevents stomach acid from attacking the underlying tissues. Frequent use of Aspirin (acetylsalicylic acid), $\text{HC}_8\text{H}_7\text{O}_2\text{CO}_2(\text{aq})$, can damage the stomach wall. Aspirin is a weak carboxylic acid with a K_a of 3.2×10^{-4} .

$\text{HC}_8\text{H}_7\text{O}_2\text{CO}_2(\text{aq})$ [eqm symbol]

$\text{H}^+(\text{aq}) + \text{C}_8\text{H}_7\text{O}_2\text{CO}_2(\text{aq})$

- a. Stomach acid has a pH of about 1.5. Given the acidity of the stomach, would Aspirin dissolved in stomach fluid be mostly in its ionized or un-ionized form?**
- b. Un-ionized Aspirin molecules can readily penetrate the stomach lining into a region of less acidity. This is where stomach irritation associated with Aspirin occurs. Use Le Chatelier's principle to explain why irritation occurs in this area.**
- c. Conduct library or Internet research to obtain information on enteric-coated tablets or capsules. How do these help alleviate the problems described in (a) and (b)?**

[Aspirin](#)

A summary of the history of aspirin, its uses, properties and chemical structure is provided.

[How Aspirin Works](#)

This site gives a detailed history of the discovery of aspirin, aspirin's properties and chemical structure, its uses, and complications that can arise from its use.

[Peptic Ulcer Disease](#)

This page describes peptic ulcers, their causes, symptoms, diagnosis, and treatment.

[Pain Relievers and Intestinal Disorders](#)

Aspirin is an example of a class of drugs called nonsteroidal anti-

inflammatory drugs (NSAIDs). This site gives a thorough discussion of why NSAIDs can damage the stomach, symptoms of NSAID-induced damage and ways in which it can be avoided.

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Question 23

During a cross-country race, the concentration of lactic acid in the fluid surrounding muscles can be 5.6 mmol/L. Given that the K_a for lactic acid is 7.94×10^{-5} , calculate the pH of the fluid around the muscles of a runner.

- a. What are the symptoms of lactic acid buildup in the muscles?**
- b. Long-distance runners make use of a quantity called the lactic acid threshold (or lactate threshold) to help them avoid lactic acid buildup. Describe the lactic acid threshold and explain how runners make use of this value in training and competition.**

[The Lactate Threshold](#)

This document describes what lactic acid is, the chemical and physiological changes that occur in muscle tissue during exercise, the effect of lactic acid concentrations on athletic performance, measuring lactate threshold and how to raise an athlete's lactate threshold.

[Elevating Your Lactate Threshold](#)

This page describes the physiological changes that occur as athletes work at their lactate threshold. Lactate threshold heart rate (LTHR) is introduced as a key indicator of a tri-athlete's fitness.

[Lactate Threshold](#)

This document defines what lactate threshold is and how to utilize lactate threshold to make training more efficient.

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Practice

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Question 11

Many communities are against the addition of fluoride to municipal drinking water. Conduct library and Internet research to learn more about this issue. List arguments for and against this practice and write a brief position paper.

[Fluorides and Human Health](#)

This page, provided by Health Canada, describes why fluoride is added to drinking water, the health risks of excessive fluoride consumption, and the federal government's role in maintaining

water quality.

[CDA Statement on Fluoridation](#)

This document is the Canadian Dental Association position paper on fluoridation.

[Fluoride: Hidden Danger in Your Drinking Water and Toothpaste](#)

This page describes why fluoride is used and the concerns with adding fluoride to our water supply.



Case Study

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Question 3

c. Conduct library or Internet research to learn about the techniques (in addition to those described here [in the Case Study]) being currently used to increase the buffering capacity (buffering ability) of granite-based lakes.

[Acid Rain](#)

This page defines acid rain, identifies sources of the pollutants responsible for acid rain, and describes the environmental effects of acid rain and possible solutions.

[Liming Acidified Lakes and Ponds](#)

Specific information regarding the use of lime to mitigate the effects of acid deposition is given.

[Acidification of Watersheds](#)

This page describes the formation of SO_x and NO_x; the environmental impact of acid deposition; the chemistry of liming; and a summary of past, current and future possible acid rain management practices.

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Explore an Issue – Take a Stand: Acting to Reduce the Effects

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a. Knowing some of the likely causes of acid deposition, research and suggest at least one action that North Americans could take to reduce the negative effects of acid deposition.

[Unfinished Business: Why the Acid Rain Problem is Not Solved](#)

This document gives current background into the sources of the pollutants responsible for acid deposition, the chemical changes that occur in soil and aquatic ecosystems as a result of acid deposition, the extent of the damage caused by acid deposition in North America, and a reflection on what still needs to be done to

alleviate the problem.

[Sources of Acid Rain-Causing Emissions](#)

This page describes the sources of SO_x and NO_x emissions, the chemical reactions that produce SO_x and NO_x, the adverse effect of acid deposition on the environment, a case study, and possible solutions.

[Air Pollution](#)

This page gives a good overview of air pollution in general, including acid deposition. The graphics provided would be useful for student presentations.

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Careers Practice

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Question 2

Select one of the careers mentioned (or a similar career of your choice) and find

- a. at least three universities that provide the necessary degree(s);**
- b. what tuition fees are at each of the universities;**
- c. what scholarships or bursaries are available to students taking these degrees.**

[Welcome to EnviroCareers](#)

Job descriptions and educational requirements for a variety of careers in the environmental sciences are provided. Chemistry-specific careers are listed in the “Protect” and “Explore” tabs.

[CareerMatters](#)

TV Ontario operates this career database. For each career, a description, specific duties, education, career path, and sometimes a videotaped interview are provided.

[JobFutures2000](#)

This resource, provided by Human Resources Development Canada, is a searchable database of careers. It provides a snapshot of 211 occupational groups; provides work experiences of recent post-secondary graduates and future outlooks for 155 different careers; and general information about the Canadian labour market.

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Chapter 8 Review

Many antacids contain carbonates such as CaCO_3 , MgCO_3 , and NaHCO_2 , as their active ingredients. Other antacids are based on hydroxides such as $\text{Al}(\text{OH})_3$ and $\text{Mg}(\text{OH})_2$.

- a. Write a chemical reaction to show how hydroxide antacids neutralize excess stomach acid.**
- b. Bicarbonate-based antacids, which contain HCO_3 as the active ingredient, are very common. Consuming excess bicarbonate can lead to a medical condition called alkalosis. Conduct library or Internet research to determine the chemical equilibrium that is involved in alkalosis.**
- c. Visit a drugstore and examine antacid labels. Which active ingredient is most common?**

[Acidosis and Alkalosis](#)

A definition of acidosis and alkalosis is provided as well as a description how athletes minimize alkalosis.

[Alkalosis](#)

This site lists the causes, symptoms, preventative measures associated with alkalosis.

[pH and Buffers](#)

This site provides a good summary of how sensitive biological systems are to slight changes in pH.

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UNIT 5: ELECTROCHEMISTRY

Chapter 9: Electric Cells

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Practice

6. Archaeometallurgy is the study of ancient metallurgy using modern analytical techniques. Give some examples of research in this field. Can a metal from one mine be distinguished from the same metal from another mine? How can this information be used in archaeological studies?

[Archaeometallurgy](#)

This simple website provides a brief description of the study of archaeometallurgy, along with a list of its major components.

[Archaeometallurgy in Archaeology](#)

This article details how archaeometallurgy is used in archaeological projects. Archaeometallurgy can be used to identify artifacts that archaeologists might not normally be able to identify.

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Section 9.1 Questions

11. Police forces use various instruments and processes to determine whether a person is legally impaired. What is the difference in operation between the Breathalyzer and the Intoxilyzer? Describe briefly how redox reactions are involved.

[How Breathalyzers Work](#)

This "How Stuff Works" website explains in very straightforward language how breathalyzers work. Not only does it explain the principles and mechanism behind the testing, but there is also a page of links provided, for other sources of information.

[Approved Breath-Test Instruments](#)

This website is provided by a Canadian company, "Forensic Consulting," that provides services in toxicology and drug identification. In this website (you can also click a button for a printable version), it explains a few different systems that can be used to detect blood alcohol levels.

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Section 9.3 Questions

13. Ursula Franklin is an internationally recognized scientist in her field. She has many interests and is outspoken on many topics. Briefly describe her pioneering scientific work and outline her views about science and technology and funding for scientific research. What other causes does she support?

[Canadian Women in Science: Ursula Franklin](#)

This National Library of Canada website is devoted to Ursula Franklin, the metallurgist and pioneer of archaeometry. It provides a biography of her busy life, along with a list of additional resources that could be consulted to find out more about her.

[Ursula Franklin: People First Technology](#)

This website contains information about an important interview with Ursula Franklin, along with an audio transcript of that interview.

[The Corrosion Resistant Delhi Iron Pillar](#)

This website contains an article from an online journal on the Delhi Iron pillar. It explains the physical uniqueness of the pillar, and uses chemistry to propose some possible explanations for the pillar's unique properties.

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Practice

13. Portable electronic devices can be found everywhere. Laptop computers, cellular telephones, mobile radios, cordless phones, portable disc and MP3 players, and digital cameras all require an electric cell.

- a. What are the requirements for cells used in these applications?**
- b. Why are some rechargeable batteries used in various portable devices supposed to be “drained” (discharged) before recharging?**

[Will Your Rechargeable Battery Die an Early Death?](#)

This website belongs to a group of websites devoted to LCD projectors, but this page explains the difference between Nickel-Cadmium and Lead Acid batteries. It provides tips for obtaining the best possible performance from these batteries.

[Rechargeable Batteries](#)

This corporate website explains the difference between a few common rechargeable batteries, focusing especially on "discharge"

characteristics.

[Rechargeable Batteries for Cordless Phones](#)

This website belongs to HelloDirect.com, which is an online telecom resource. The site is devoted exclusively to rechargeable batteries for cordless phones.

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Practice

14. Moli energy of Maple Ridge, BC was the first company in the world to develop a commercial, rechargeable lithium cell called a Molicel. Research the characteristics and advantages of Molicels compared with other secondary cells.

[Molicell Lithium-Ion 18650 Cell](#)

This corporate website provides basic information for batteries that are used in industry. The website covers the advantages of one particular cell, and contains a link to its full datasheet.

[Lithium Ion Batteries: A Profitable Future](#)

This website provides a report on the lithium-ion batteries produced by Nippon Moli Energy Corporation, a company that resulted after a Japanese company bought a Canadian company.

[Searching for the Perfect Battery Cell](#)

This media release from Simon Fraser University in British Columbia describes the university's scientists pursuit of the perfect battery.

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Practice

21. Plastic batteries were the dream of the 1980s, the disappointment of the 1990s, and the subject of the 2000 Nobel Prize for Chemistry. Now it appears that some commercial products will eventually result from the research and development invested in plastic batteries. Briefly describe the electrodes and electrolyte for a plastic battery. How is this battery similar to and different from an ordinary battery? What are some of the advantages and disadvantages?

[Hopkins Scientists Create All-Polymer Battery](#)

This article describes a technological development made by scientists at Johns Hopkins University. The "plastic" battery is described, and its many advantages and potential uses are mentioned.

[Alan MacDiarmid, Conductive Polymers, and Plastic Batteries](#)

Along with a link to many additional resources, this website of the Office of Scientific and Technical Information discusses MacDiarmid (Nobel Prize Winner in 2000) and his role in developing cells from polymers.

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Explore an Issue – Debate: Hydrogen Fuel Cells

In your research, consider:

- where does the hydrogen come from?
- from source to final end product, are hydrogen fuel cells nonpolluting?
- other perspectives, such as economic, social, political, and technological.
- alternative to the hydrogen fuel cell.

[Automobiles Using Fuel Cells](#)

This website was produced by scientists at Michigan State University. It explains very systematically and clearly how automobile fuel cells work. The authors also provide an explanation of much of the background science required to understand fuel cells.

[Life-Cycle Value Assessment \(LCVA\) for Fuel Cell Vehicles in Canada](#)

This publication is provided by the Pembina Institute, a non-profit environmental organization dedicated to promoting awareness of critical environmental issues in Canada. This report examines the impact of the adoption of fuel cell cars in Canada.

[Heading Towards a Hydrogen Future](#)

This May 2000 article was written by David Suzuki. In it, he explores both the positive and negative sides of the fuel-cell debate, arguing primarily that if hydrogen fuel cells are to be adopted, we must ensure that the hydrogen is obtained in a responsible manner.

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Section 9.4 Questions

9. People whose heart occasionally beats too slowly or too quickly often have pacemakers to keep the heart beating regularly. Pacemakers use a battery for electric power. What kind of battery is commonly used today? How does the doctor know when the battery is nearing the end of its life and needs to be replaced? Why are rechargeable batteries generally not

used?

[History of Pacemakers](#)

This corporate website belonging to Medtronic covers the evolution of the pacemaker, from the earliest "external" pacemakers of the 1950s to the computer-like models of the new millennium.

[Pacemakers](#)

This Web site addresses some of the most frequently asked questions about pacemakers, such as how they work, how they are implanted, and whether pacemaker patients are safe around electrical devices.

[When Your Battery Goes Down](#)

This website provided by GlobalClassroom.org has many questions and answers about pacemakers, including questions about what one does when the battery in a pacemaker dies.

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Section 9.6 Questions

10. A zinc wire is connected to and buried with a pipeline when it is built.

- a. Why is this done? Include a brief description of the principles involved.**
- b. Is this the only type of corrosion protection used with major pipelines?**
- c. Discuss the environmental and safety issues associated with protecting and also not protecting pipelines.**

[Pipeline Corrosion Protection](#)

This corporate website contains links to other pages with information about the various products that Pollyaim Ltd makes in order to help protect pipelines from corrosion.

[Pipeline Corrosion](#)

This website is provided by NACE, the National Association of Corrosion Engineers. In this webpage, they describe the various forms of protection available for preventing pipeline corrosion: coatings and linings, cathodic protection, materials selection, and corrosion inhibitors.

[Corrosion Protection Systems](#)

This corporate website explains the services of an Australian company that protects various industries (telecommunications, oil, water, etc.) from damage due to corrosion in a variety of projects.

[NTSB Determines that Inadequate Corrosion Protection Caused Fatal Pipeline Rupture](#)

This website contains a press release from the U.S. National Transportation Safety Board, stating that a pipeline rupture that led to two deaths was caused by a company's negligence in providing adequate corrosion protection for the pipeline.

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UNIT 5: ELECTROCHEMISTRY

Unit 5 – Performance Task and Review

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Question 36

Battery technology is a very active area of research. One proposal that shows some promise is a vanadium redox flow cell, also known as the All Vanadium Redox Battery. Describe the general construction of this battery, including electrodes, electrolytes, porous boundary, and external tanks. What redox reactions occur at the electrodes within this cell? List some unique aspects of this technology, as well as some advantages and proposed uses.

[The Vanadium Redox Battery](#)

This website is provided by the University of New South Wales in Australia, where the vanadium redox battery was invented. The entire site is devoted to this particular battery, with several links pointing to different types of information about it. A picture gallery is also provided.

[Vanadium Battery Info](#)

This private website contains several links to various websites, all of which have something to do with vanadium batteries. There is an especially large amount of information on worldwide patents that are held on the battery, and other issues of interest to corporations.

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Question 38

Road salt is commonly used on Canadian roads, mostly during the winter months. Recently, this use has become an issue and Environment Canada is assessing whether road salt should be classified as a “toxic substance.” What is “road salt?” Compare Ontario’s use of road salt with that of other provinces. Describe some benefits of road salt related to its use, and some environmental and safety issues, including specific examples related to electrochemistry and other areas. What are some

alternatives to the current use of road salt?

[Use of Road Salt for De-Icing](#)

This website contains a report that was addressed to the government officials of the City of Vancouver. In it, the General Manager of Engineering Services discusses alternatives to, and substitutes for, de-icing salt, along with a comparative cost analysis of the various options.

[Smarter Roads Mean Safer Roads](#)

This Environment Canada website discusses the installation of many hi-tech Road Weather Information Systems, which regularly monitor road surfaces to forecast anti-icing needs for roads. The key to this paper is the goal to lay road salt or brine down on roads before ice begins to accumulate.

[Road Salts an Environmental Concern](#)

This Environment Canada website addresses the environmental concerns about the continued use of road salt on Canadian roads. It discusses issues such as contamination of bodies of water, and the resultant impact on plants and animals.

[Science Assessment Finds Road Salts Toxic to the Environment](#)

This website contains an archived report from Environment Canada. Rather than simply raising potential problems with road salt use, this report quantifies the problem by naming specific toxins, and estimating how much damage they are actually doing to our environment.

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Question 40

Most chemical reactions are explained as being either electron transfer reactions or proton transfer reactions.

- a. What are the similarities and differences between electron and proton transfer reactions?**
- b. State some evidence for energy changes in both electron and proton transfers.**
- c. Identify a combination of chemicals that might produce either an electron or a proton transfer reaction, and describe some diagnostic tests that could be used to determine which reaction predominates.**

[The Fall of the Electron](#)

This Simon Fraser University website explains how we can use "electron falling" to explain why a certain reaction might go in one direction only, and not in the reverse. It argues that by treating reactants as electron sources, one can use the free energy of an electron to predict which way the electron will go.

[The Fall of the Proton](#)

This Simon Fraser University website uses "proton falling" to explain why acids react with bases. It essentially revives a certain view, the "proton-free-energy" view, espoused by a scientist in the 1950s.

[Theories of Charge Transfer and Transport](#)

This scientific website from an American university contains information about a specific laboratory's activities in the area of researching charge transfer. Dr. Cukier uses simulations to study both electron and proton transfers in solutions.

[Proton-Coupled Electron Transfer](#)

This Massachusetts Institute of Technology website discusses a specific process in biological systems known as proton-coupled electron transfer (PCET). This method is described as the basic mechanism for all bioenergetic conversions.

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UNIT 5: ELECTROCHEMISTRY

Chapter 10: Electrolytic Cells

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Practice

6. Research and describe some of the variety of uses of aluminum summarized in the exhibition, “Aluminum by design: Jewellery to Jets.”

[Aluminum by Design: Jewelry to Jets](#)

Hosted by the Carnegie Museum of Art, this website is devoted to an exhibition that houses examples of the various uses to which aluminum has been put throughout history.

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Practice

7. Research and describe the newer, ion-exchange membrane cell design for the chlor-alkali process. Include a labelled cell diagram and the function of the membrane. Why is it superior to other designs?

[Chlor-Alkali Membrane Cell Process](#)

This group of websites is known as the Chemical Engineers' Resource Page. This site explains the use of the chlor-alkali membrane cell, using easy-to-read text and diagrams.

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p. 742 Explore an Issue – Take a Stand: The Case For and Against Chlorine

- a. Research the production, storage, transportation, and uses of chlorine and assess one environmental, health, or safety issue.**
- b. What is the best resolution of the issue you assessed? Present your findings in a way designed to influence decision makers. Include an outline of your findings in your presentation.**

[Chlorine Saves Lives](#)

Hosted by the Chlorine Chemistry Council, this website explains many everyday uses of chlorine, and contains several links to other

websites with information about chlorine. It is a very useful starting point.

[Chlorine Bleaches Out Life](#)

The Chlorine Free Products Association represents "companies dedicated to implementing advanced technologies, and/or, groups supporting products free of chlorine chemistry." Some information about its stance can be found on this website in its News page and its online Newsletter.

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Practice

13. There are companies that specialize in bronzing baby booties, sports equipment, and keepsakes. Find one and research the service it offers.

- a. How does it make a nonconductor like a shoe into an electrode? Which electrode?**
- b. Briefly describe the process and the approximate costs for typical items.**

[Caswell Plating](#)

Explore the website for Caswell Plating, a company that provides a wide range of plating kits and plating supplies. There is a tutorial on electroplating on the Plating Kits page of the website (the tutorial requires Flash).

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Practice

14. Electroplating industries produce considerable waste that is expensive to manage and an environmental hazard if not treated properly. List four different types of electroplating waste, including potential hazards. Describe some ways companies reduce, recover, and treat electroplating wastes.

[Electroplating Shops – Watch Your Waste](#)

This website is sponsored by the U.S. state of Illinois' Environmental Protection Agency. It provides information for companies and industries involved in electroplating, giving them tips on the laws that apply to them, as well as hints in reducing and preventing pollution.

[Reducing Recycling Costs](#)

This website is hosted by the Argonne National Laboratory, which belongs to the U.S. Department of Energy. They have developed a new process for disposing wastes that result from several common

electroplating processes.

[Pollution Solutions: Metal Finishing](#)

This website from the Office of Waste Management of the University of Missouri provides many tips and strategies that businesses and industries can use to dispose of, and safely use, many metal finishing by-products. The recommendations are very well organized and clearly laid out.

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Practice

15. Aluminum cans are widely used for beverages. Write a short report about the production of aluminum cans, including how the can is made, how the top is attached to the can, how the construction of the can has changed since the first model, and the advantages of using recycled aluminum instead of new aluminum.

[The Life Cycle of an Aluminum Can](#)

This corporate website will take you through the five major phases in the life of an aluminum can. It uses easy-to-read text along with diagrams and charts in order to explain how most aluminum cans are created, used, and recycled.

[Fun Facts on Can History](#)

This website provides some interesting and little-known facts about aluminum can history and recycling. The social history of the aluminum can is actually quite interesting.

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Practice – Careers

16. Research one of the careers listed, or another related career that may interest you. Write a report that

- a. provides a general description of the work and how it is related to metals;**
- b. describes the education and training required;**
- c. outlines the current opportunities in this area, including typical salaries.**

[Jobs Starting With M](#)

See how many jobs there are that begin with the word, “metal.” This website provides an excellent start for investigating any career.

[Occupational Descriptions](#)

This website is provided by the government of Ontario’s Ministry

of Education. It contains a vast array of resources that you can use to find job descriptions and qualifications for all sorts of different occupations.

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Section 10.2 Questions

11. The loonie replaced the one-dollar bill, which typically wore out in the space of a few months. The Royal Canadian Mint wanted to produce a dollar coin with a richer sheen than the shiny metals used in coins of lower value. Sherritt Gordon of Fort Saskatchewan, AB developed a unique process for plating the loonie coin.

- a. Research the production and composition of the loonie.**
- b. What is the golden “aureate” finish on the loonie? Describe the materials and process for producing the finish.**
- c. Why did the coin end up with a loon stamped on it?**

[One Dollar](#)

This website of the Royal Canadian Mint explains the loonie’s significance and history. You can find out not only about what types of design changes have taken place since the loonies was introduced, but you can also find out the technical specifications (actual composition) of the coin.

[Westaim’s Aureate](#)

This corporate website promotes the coinage material, aureate, that it manufactures. It discusses the properties of this material and promotes the advantages that this material exhibits.

[Electroplated Coinage Technology](#)

This corporate website discusses Westaim’s coin development process. It discusses the development and production of various coinage materials, the operation of its plants, and a brief promotional history of its company.

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Chapter 10 Review

19. Plastic components used in the automotive and electronic industries are often electroplated with chromium, nickel, or copper to give them a metallic appearance. The two major challenges for electroplating are to make the surface of the material electrically conductive and to effectively bond the metal to the plastic.

- a. How is plastic made electrically conductive?**
- b. How is the metal bonded to the plastic?**
- c. What are some of the limitations/problems associated with electroplating plastics?**

[How We Electroplate](#)

This corporate website explains the process of electroplating, as it relates to Borough's products and services. A few diagrams are also provided for clarity.

[Plastic Plating](#)

This corporate website describes one of the services that the company offers: plastic plating. It uses a few enlargeable photographs and captions to demonstrate its product.

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Chapter 10 Review

20. Sludge and wastewater from electroplating processes contain chromium, copper, nickel, and silver, as well as cyanide ions. Sending these metals to landfill or discharging them in wastewater, instead of recycling them, is detrimental to the environment and wasteful of energy. Technologies are being developed to separate and purify these metals, including precipitation, electrolysis, and reverse osmosis. Research one technology designed to reduce the environmental impact of the electroplating industry, and write a short account of how it works.

[Water Recycling Costs](#)

This corporate website describes Remco Engineering's recommendations regarding, and discussion concerning, the various methods that are available for recycling water used in electroplating. It discusses four types of systems, their advantages and disadvantages.

[Hexavalent Chromium Waste Treatment](#)

This corporate resource document describes a method available to dispose of hexavalent chromium waste, a carcinogenic chemical that became infamous after the wide coverage it received due to the movie, Erin Brokovich.

[Cleaner Production](#)

This New Zealand government website describes an approach that it recommends for businesses and other organizations, called "Cleaner Production." It describes the advantages of such an approach, and elaborates on government programs that will support any business/organization's endeavour to place a greater emphasis on the environment.

[GE Betz](#)

This website provides links to the various products and services

offered by GE Betz, a subsidiary of General Electric, who are “shaping the future of water and process treatment.”

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