Unit 3
Physical Science:
Chemical Reactions

Unit Overview

Introduction

After students have developed an understanding of atomic structure and the periodic table in grade 9, the study of chemical reactions provides them with an opportunity to apply their understanding of atomic structure to how chemicals react. By naming and writing common ionic and molecular compounds, and by balancing a variety of equation types, students begin to make connections to a variety of chemical examples in everyday life.

Focus and Context

This unit emphasizes the social and environmental contexts of science and technology associated with air and water pollution, and should have a principal focus of observation and inquiry. However, there are opportunities for decision making as well as design technology in the laboratory research components of this unit. Atlantic Canada offers a possible context for this unit because it is particularly affected by acid precipitation and other forms of air pollution owing to prevailing winds in North America. These winds carry large amounts of air pollutants from the more populated and industrialized regions of the United States and Canada. The problem is further complicated by our own industrial plants and power generation plants. In addition, much of our region has thin soils and granite bedrock, which results in a high sensitivity to acid damage. In this context students will consider how chemical reactions are associated with technologically produced problems such as acid rain, and look at some steps that can be taken to counter the effects of acid rain.

Curriculum Links

The study of chemical reactions in Level I connects readily with topics covered as early as pimary where students are introduced to chemical/physical properties, liquids and solids and the nature of chemical change. These early considerations of states of matter are given more attention and detail in elementary as properties and changes in materials are studied. By grade 7, students cover in some detail the concept of mixtures and solutions. As mentioned in the above paragraph, there are very strong links between the topics of atomic structure in grade 9 and the chemistry studied in Level I. For those who pursue chemistry in Level II and Level III the material covered in grades 7, 9 and Level I offers a solid foundation to build on as students undertake a more detailed look at traditional chemistry topics such as acids and bases, solutions, stoichiometry, and electrochemistry.

Curriculum Outcomes

(From the K-12 Pan Canadian Science Framework Document)

Students will be expected to

STSE

Nature of Science and Technology
114-8 describe the usefulness of scientific nomenclature systems

Relationships between Science and Technology
116-3 identify examples where technologies were developed on the basis of scientific understanding

116-5 describe the functioning of domestic and industrial technologies, using scientific principles

Social and Environmental Contexts of Science and Technology
117-1 compare examples of how society influences science and technology

117-5 provide examples of how science and technology are an integral part of their lives and community

117-7 identify and describe science- and technology-based careers related to the science they study

118-5 defend a decision or judgment, and demonstrate that relevant arguments can arise from different perspectives

SKILLS

Initiating and Planning
212-3 design an experiment, identifying and controlling major variables

212-8 evaluate and select appropriate instruments for collecting evidence and appropriate processes for problem solving, inquiring, and decision making
Performing and Recording

213-2 carry out procedures controlling the major variables and adapting or extending procedures where required

213-5 compile and organize data, using appropriate formats and data treatments to facilitate interpretation of the data

213-9 demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials

Analysing and Interpreting
214-5 interpret patterns and trends in data, and infer or calculate linear and non linear relationships among variables

214-15 propose alternative solutions to a given practical problem, identify the potential strengths and weaknesses of each, and select one as the basis for a plan

Communication and Teamwork
215-6 work co-operatively with team members to develop and carry out a plan, and troubleshoot problems as they arise

KNOWLEDGE

319-2 (I) classify substances as acids, bases, or salts, based on their characteristics

321-2 describe how neutralization involves tempering the effects of an acid with a base or vice versa

319-1 (I) name and write formulas for some common molecular compounds, including the use of prefixes

319-1 (II) name and write formulas for some common ionic compounds (both binary and complex), using the periodic table, a list of ions, and appropriate nomenclature for metal and non-metal ions

319-2 (II) classify substances as acids, bases, or salts, on the basis of their names and formulas

319-3 illustrate, using chemical formulas, a wide variety of natural and synthetic compounds that contain carbon

321-1 represent chemical reactions and the conservation of mass, using molecular models and balanced symbolic equations

321-3 illustrate how factors such as heat, concentration, light, and surface area can affect chemical reactions

Physical Science: Chemical Reactions

Investigating chemical reactions is a key to understanding nature.

Outcomes

Students will be expected to

- provide examples of how science and technology are an integral part of their lives and their community by investigating common examples of combustion (117-5)
  - define chemistry and matter
  - identify examples of chemistry and technology around them in everyday life

- demonstrate a knowledge of WHMIS standards by selecting and applying proper techniques for handling and disposing of lab materials (213-9)
  - describe the WHMIS information system and its use
  - identify the eight WHMIS symbols
  - describe the MSDS sheet and its use
  - identify the nine categories on a MSDS sheet

- using problem solving, evaluate and select appropriate methods/tests to investigate the presence of chemicals (212-8)
  - these include O_2, H_2, CO_2, H_2O, acids, bases and salts

Elaboration – Strategies for Learning and Teaching

Students should observe and describe several chemical reactions that are an integral part of their daily lives. Teachers should give students the opportunity to appreciate that chemical reactions occur all around them everyday. For example, oxidation of iron (i.e., rusting), combustion of wax, vinegar (CH_3COOH) and baking soda ($NaHCO_3$), and so on. In keeping with an acid rain theme, students could observe the combustion of sulfur dioxide. The sulfur dioxide can be bubbled through water to produce sulfurous acid (simulated acid rain). Acid rain production could be checked using pH paper. This activity could set up the SBE context (acid rain) for the remainder of the unit.

Safe practices and proper use of equipment are very important in the laboratory. For all laboratory activities in this unit, teachers should ensure students recognize WHMIS standards.
Any chemicals purchased by the school will come with a MSDS sheet that students can investigate. One example of a MSDS sheet is provided in the Appendix.

Presence of various chemicals should be determined by various tests. These should include (but not be limited to):

(i) oxygen gas *(glowing splint)*
(ii) hydrogen gas *(lit splint)*
(iii) carbon dioxide *(lime water)*
(iv) water *(cobalt chloride paper)*
(v) acid *(litmus paper)*
(vi) base *(litmus paper)*
(vii) aqueous solution of salt *(conductivity apparatus)*

Many of these tests are part of the Grade 9 science curriculum; however, a brief review may enhance the introduction of the chemistry unit. These chemical tests provide an opportunity for students to develop/practice proper laboratory techniques.
It is expected that students would select and carry out an appropriate test to determine an unknown chemical substance. For example, students could determine what gas is produced when chaulk ($CaCO_3$) is reacted with vinegar (CH_3COOH) and/or the gas produced when magnesium ribbon (Mg) is reacted with hydrochloric acid (HC1(aq)).

Physical Science: Chemical Reactions

Investigating chemical reactions is a key to understanding nature.

Suggested Assessment Strategies

- *This unit requires practical experiences in the laboratory and several factors may contribute to student assessment.*

Performance

Students could research, list, and present the various forms of fuels used for domestic heating in their home community. (117-5)

Paper and Pencil

Students could make a list of household chemicals. In a group, they could divide up this list and check the WHMIS data sheets to see how these chemicals should be handled and stored. They should record their findings in a group table and post it on the wall. (213-9)

Resources

Science 10

pages 170-171; 176-178

page 174

pages 654-660

Appendix

Science 10 TR

page 2-240

See Appendix B

Science 10

pages 173-174; 180; 290-291; 296; 300-301

Physical Science: Chemical Reactions

An introduction to formula writing.

Outcomes

Students will be expected to

- describe the usefulness of IUPAC scientific nomenclature systems to convey chemical information (114-8)
  - define molecule, molecular formula, empirical formula, polyatomic ion, simple ion, and formula unit
  - define aqueous solution (aq)
  - define electrolyte and nonelectrolyte (electrolytic and nonelectrolytic solution)
  - distinguish between physical and chemical property
  - distinguish between physical and chemical change
  - differentiate between ionic and molecular compounds
    (I) based on their composition and bonding
    (II) based on their physical properties (Core Lab)

- name and write formulas for common molecular compounds, including the use of prefixes (319-1)
  - determine the names of binary molecular compounds, using IUPAC rules, given the molecular formulas and vice versa
  - name several molecular compounds using trivial names

Elaboration – Strategies for Learning and Teaching

IUPAC stands for International Union of Pure and Applied Chemistry. Teachers could use molecular models to demonstrate correct naming and writing of molecular formulas for a variety of molecular compounds such as methane, water, hydrogen peroxide, ozone, sucrose, ethanol, and methanol. It is important to cover not only common names such as methane (CH_4) but also the systematic approach of using prefixes mono, di, tri, and so on for binary compounds such as sulphur dioxide and sulphur trioxide. Through using IUPAC nomenclature students should start to appreciate the usefulness of a common naming system. Teachers should point out to the students that molecular compounds consist of non-metals while ionic compounds consist of metals and non-metals. It should also be noted that acids usually start with hydrogen.

Aqueous Solution: solution in which water is the solvent

Molecular Formula: chemical formula which denotes the number and type of different atoms in a molecule

Empirical Formula: simpliest chemical formula that can be written for a compound (smallest whole number ratio of atoms)

Example:	water	- H_2O	- Molecular Formula
		- H_2O	- Empirical Formula
	hydrogen peroxide	- H_2O_2	- Molecular Formula
		- H O	- Empirical Formula

I Ionic compounds

(i) involve the transfer of electron(s) resulting in ionic bonding

(ii) made up of two oppositely charged ions (metal and nonmetal, or combination involving a complex ion)

(iii) exist in the form of an ionic crystal lattice (not individual molecules)

II Binary molecular compounds

(i) involve the sharing of electrons resulting in covalent bonding (simple electron dot diagrams for diatomic molecules will illustrate this)

(ii) composed of two nonmetals

(iii) exist as individual molecules

Physical Science: Chemical Reactions

An introduction to formal writing.

Suggested Assessment Strategies

Journal

Students could research the introduction of the IUPAC naming system, as well as the ACS (American Chemical Society) naming system, and determine their roles in naming compounds. They should debate the need for a standard system for naming compounds. (319-1)

Resources

Science 10

pages 186-187; 196

pages 201-202

pages 180, 184

Core Lab: *"Properties of Ionic and Molecular Compounds."*
- Appendix A

pages 201-204

The concept of bonding capacity should be omitted.

Physical Science: Chemical Reactions

An introduction to formula writing.

Outcomes

Students will be expected to

- name and write formulas for common molecular compounds, including the use of prefixes (319-1) Cont'd

Elaboration – Strategies for Learning and Teaching

Note the textbook only gives prefixes to 5, the following prefixes should also be included

hexa 6	nona 9
hepta 7	deca 10
octa 8	

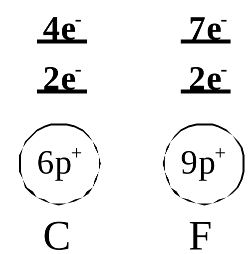
There are many chemical compounds that are named using trivial names. Students should be able to name the following compounds using trivial names:

H_2O	water	H_2O_2	hydrogen peroxide
NH_3	ammonia	H_2S	hydrogen sulfide
$C_{12}H_{22}O_{11}$	sucrose		

Students should know that some elements exist naturally as polyatomic molecules: H_2, N_2, O_2, and halogens (F_2, Cl_2, Br_2, I_2, At_2) are diatomic, sulfur as S_8 and phosphorous as P_4

- name and write formulas for some common ionic compounds (both binary and complex), using the periodic table, a list of ions, and appropriate nomenclature for metal and non-metal ions (319-1)
  - given formulas for ionic compounds (including simple ions and polyatomic ions, ions that can form multiple charges, and ionic hydrates), determine the names of ionic compounds using IUPAC rules and vice versa

Students will be expected to have some knowledge of ions and their relationship to atomic structure and the periodic table from grade 9. However, a review of these points should be done at this time. Students should use energy level diagrams instead of the orbit models presented in their text book. Some examples of energy levels diagrams are to the right.



Students should practise naming and writing of ionic formulas such as CaO [calcium oxide], $Ca(OH)_2$ [calcium hydroxide] , $CaCO_3$ [calcium carbonate], $CaSO_4$ [calcium sulphate], associated with acid rain, along with others such as NaCl [sodium chloride], NaOH [sodium hydroxide]. The use of Roman numerals should also be covered for compounds such as FeO [iron (II) oxide] and Fe_2O_3 [iron (III) oxide]. An activity using aides such as ion clips would be very helpful at this point.

Naming ionic hydrates:

name ionic part as usual and use prefix to indicate the number of water molecules per formula unit

Example: $CuSO_4 \cdot 5H_2O$
copper (II) sulfate pentahydrate

This topic is important for chemistry courses that follow. Teachers should involve students in finding a variety of ways to gain a knowledge of nomenclature.

Note: Periodic table of ions as well as table of polyatomic ions will be provided.

Physical Science: Chemical Reactions
An introduction to formula writing.

Suggested Assessment Strategies

Paper and Pencil

Students could design a flowchart to be used for naming compounds. (319-1)

In order to ensure a good understanding of nomenclature, it is advisable that the teacher give several quizzes, followed by a major test.

Paper and Pencil

Stations can be set up in the lab to test students on formula writing. Stations could include compound formulas to name, names to write formulas for, 3-D models to determine the names of, and so forth. (319-1)

Presentation and Performance

Students could work in groups to design a game for naming ionic or covalent compounds. Students could test their games on other groups in the class. (319-1)

Resources

Science 10

pages 184-198; 236

Science 10 TR

p. 2-250 to 2-252

Physical Science: Chemical Reactions

An introduction to formula writing.

Outcomes

Students will be expected to

- classify simple acids, bases and salts on the basis of their names and formulas: [319-2 (II)]
  - name and write formulas for some common acids and bases, using the periodic table, a list of ions, and rules for naming acids
  - define acids as molecules that ionize in water to produce hydrogen ions (H^+)
  - identify the physical properties of acids
  - define bases as ionic compounds that contain the hydroxide ion
  - define salts as ionic compounds

Elaboration – Strategies for Learning and Teaching

They should also be introduced to the rules for writing and naming common acids.

- Note students would not be given the rules in testing situations
- It should be emphasized that these rules propose that acids be named as if they were ionic and then be converted to the correct acid name

1.	hydrogen _____ide	becomes hydro____ic acid
Ex:	hydrogen chloride	becomes hydrochloric acid
	HCl	$HCl(aq)$
2.	hydrogen _____ate	becomes ______ic acid
Ex:	hydrogen sulfate	becomes sulfuric acid
	H_2SO_4	$H_2SO_4(aq)$
3.	hydrogen _____ite	becomes ____ous acid
Ex:	hydrogen nitrite	becomes nitrous acid
	HNO_2	$HNO_2(aq)$

NOTE: *when sulf is the root we add "ur" and when phosph is the root we add "or" to make it sound better.*

Definition of acid provided here has limitations but is adequate for the purpose intended for this course.

Acid physical properties should be determined in a way similar to the way the properties of ionic and molecular compounds were identified. There will be more extensive determinations later. Note the physical properties of acids do not fit in either the ionic or molecular category. They are a special case. (See note to teacher in Appendix Core Lab #1)

Physical Science: Chemical Reactions

An introduction to formula writing.

Suggested Assessment Strategies

Journal

Students could write their own definitions of acids, bases and salts from their laboratory experiences. (319-2)

Resources

Science 10

page 295

pages 293-294

Physical Science: Chemical Reactions

An introduction to formula writing.

Outcomes

Students will be expected to

- classify substances as acids, bases, or salts, on the basis of their characteristic properties (319-2)
  - define pH scale in terms of a measure of acidity or alkalinity or neutrality.
  - define acids and bases operationally in terms of their effect on litmus paper, pH, sour and bitter taste, reaction with active metals, and reaction with each other
  - define salts operationally in terms of the conductivity of their aqueous solutions
- describe how neutralization involves tempering the effects of an acid with a base and vice versa (321-2)

Elaboration – Strategies for Learning and Teaching

Students should determine the presence of an acid, base, salt, carbon dioxide, and water by performing tests with pH paper, limewater, cobalt chloride paper, and a conductivity apparatus. If electronic equipment such as graphing calculators, pH sensors, CO_2 sensors, are available, their use should be encouraged at this point. Students can test common substances in the home to see if they are acidic, basic, or neutral. A microscope can also be used with a paramecium culture and dilute sulphurous acid to see the effects of acid rain on micro-organisms.

A detailed study of acids, bases, pH, and so forth is not expected at this point, but students should have a basic understanding of simple diagnostic tests associated with acids, bases, salts, and the major products of combustion. This activity should include the information that acids have a sour taste *(if edible)*, turn blue litmus red, react with active metals, conduct electricity, and neutralize bases. By contrast, bases are bitter, feel slippery, turn red litmus blue, and neutralize acids, and salts conduct electricity but do not change the colour of litmus papaer.

Students should illustrate the neutralizing properties of calcium oxide (lime) by reacting it first with water (thus making the base calcium hydroxide) and subsequently with dilute sulphuric acid. This would simulate neutralizing a lake that has been affected by acid precipitation. Alternatively, other combinations of acids and bases can be used. Students should check the pH with either pH paper or a pH meter as they proceed with each step. Electronic equipment such as CBLs (Calculator Based Laboratories) or Sense and Contol units can also be used here if available.

This can be emphasized again but it should have been done as part of the double replacement reactions.

Physical Science: Chemical Reactions

An introduction to formula writing.

Suggested Assessment Strategies

Performance

Students could bring household chemicals from home, and, with permission from their teacher, test them to classify them as acid, base, or salt. They should record their results in a chart, and indicate the instruments and techniques used to achieve this. (319-2, 212-8)

Resources

Science 10

pages 293-295

pages 296-299

pages 290-295

page 180

pages 314-319

Physical Science: Chemical Reactions

An introduction to equation writing.

Outcomes

Students will be expected to

- represent chemical reactions and the conservation of mass, using molecular models and balanced symbolic equations (321-1)
  - write and balance reactions that illustrate a variety of reaction types, including combustion, formation, decomposition, single replacement, and double replacement
  - define the law of conservation of mass
  - list the four pieces of evidence for a chemical reaction
  - predict the products of chemical reactions, indicating the phase of all reactants and products (including the use of a solubility table for reactions in solution)
  - define exothermic and endothermic reactions and draw energy diagrams representing each

Elaboration – Strategies for Learning and Teaching

Students should balance different types of chemical reactions and confirm the conservation of atoms, using molecular models. They should be introduced to identifying reactants and predicting the products of a reaction. Here are some suggestions:

The use of 3-D models allows students to better visualize how natural systems operate and scientific concepts are applied. A full knowledge of accurate molecular structures is not required in Level I, but molecular models should be used so that the students have some knowledge of which atoms are attached to which atoms.

Students should be able to predict products for simple chemical reactions by the time they have finished this section.

1. Combustion
   (i) products of combustion reactions involving hydrocarbons (organic compounds with C's and H's) as well as those that contain C's, H's and O's react with oxygen to produce CO_2 and H_2O.
   (ii) products of the above noted reactions that undergo incomplete combustion (due to insufficient oxygen) include CO and C.
2. Formation (combination)
   (i) Metal + Nonmetal produces ionic compound
   Ex: $4\,Al(s) + 3\,O_2(g) \rightarrow 2\,Al_2O_3(s)$

Teachers choosing an acid rain context will need to discuss acid producing formation reactions such as the following.

1. $C(s) + O_2(g) \rightarrow CO_2(g)$
2. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + H_2O(l)$
   (or any hydrocarbon)
3. $CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$
   carbonic acid

OR

1. $S_8(s) + 8O_2(g) \rightarrow 8SO_2(g)$
2. $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$
   sulphurous acid

These reactions are also types of formation reactions. It is not necessary for students to know how to predict these formation reactions; however, for reference they are given below:

(ii) Metallic oxide + water produces metallic hydroxide (base)
Ex: $CaO(s) + H_2O(l) \rightarrow 2\,Ca(OH)_2(s)$

(iii) Nonmetallic oxide + water produces acid
Ex: $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$

(iv) Metallic oxide + carbon dioxide produces metallic carbonate
Ex: $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

Physical Science: Chemical Reactions

An introduction to equation writing.

Suggested Assessment Strategies

Performance

Students should receive encouragement for making and using three-dimensional models for presentations and balancing chemical equations. Three-dimensional models constructed by students can be assessed by the teacher for correctness with regard to the attachment of atoms to other atoms and the conservation of atoms in chemical reactions. (321-1)

Paper and Pencil

Students could write a balanced equation and indicate the reaction type (combustion, formation, decomposition, single replacement, or double replacement) for each of the following:

1. $H_2O(l) \rightarrow H_2(g) + O_2(g)$
2. $Cl_2(g) + LiI(aq) \rightarrow LiCl(aq) + I_2(s)$
3. $KOH(aq) + H_3PO_4(aq) \rightarrow K_3PO_4(aq) + H_2O(l)$
4. butane (gas) + oxygen (gas) $\rightarrow$ carbon dioxide (gas) + water (vapour)
5. solid sodium + chlorine (gas) $\rightarrow$ solid sodium chloride (321-1)

Resources

Science 10

pages 216-221; 226-247

pages 220-225

pages 281-283

Physical Science: Chemical Reactions

An introduction to equation writing.

Outcomes

Students will be expected to

- represent chemical reactions and the conservation of mass, using molecular models and balanced symbolic equations (321-1) Cont'd

Elaboration – Strategies for Learning and Teaching

3. Decomposition
   (i) Binary compound which produces the elements which compose it
   Ex: $H_2O(l) \rightarrow H_2(g) + O_2(g)$

It could be noted that the reverse of any formation reaction is a decomposition reaction. In practice, however, it may be very difficult to actually reverse a formation reaction.

Generally, single and double replacement reactions take place in solution. Core Labs # 2 and # 3 are short and could be combined into one lab.

4. Single Replacement (Single Displacement)
   (i) metal + ionic compound
   Ex: $Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4$
   (ii) nonmetal + ionic compound
   Ex: $Cl_2(aq) + 2NaBr(aq) \rightarrow 2NaCl_2(aq) + Br_2(l)$
   (iii) metal + acid
   Ex: $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

5. Double replacement (Double Displacement)
   (i) two ionic compounds
   Ex: $AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaCl(aq)$
   (ii) acid + base (neutralization)
   Ex: $3NaOH(aq) + H_3PO_4(aq) \rightarrow Na_3PO_4(aaq) + 3H_2O(l)$

Physical Science: Chemical Reactions

An introduction to equation writing.

Suggested Assessment Strategies

Performance

As a culminating exercise, a concluding assessment to this section may include a simple practical exam. This should be designed around simple skills and knowledge acquired in the suggested activities. (212-3, 212-8, 213-2, 213-5, 213-9, 214-15)

Resources

Core Lab # 2 (a): *"Single Displacement Reactions"*, pages 242-243

Core Lab # 2 (b): *"Double Displacement Reactions"*, pages 244-245

Physical Science: Chemical Reactions

What are some of the effects of industrialization and associated pollution?

Outcomes

Students will be expected to

The following outcomes could be covered as an independent student project which may extend beyond the time lines of the chemistry section of Grade 10 Science.

Students will be expected to

- work co-operatively with a team to research and describe the relationship between domestic and industrial technologies and the formation of acid rain (116-5, 215-6, 116-3)
- compile and organize data on acid precipitation (pH) in order to interpret patterns and trends in these data, and infer or calculate linear and non-linear relationships among variables such as pH versus time and location (213-5,214-5)
- propose alternative solutions to the problem of acid precipitation, assess each, and select one as the basis for a plan of action, defending the decision (214-15, 118-5)
- identify and describe science-and technology-based careers related to airborne pollution (117-7)
- compare examples where society has used the presence of airborne pollution to influence decisions concerning science and technology (117-1)

Elaboration – Strategies for Learning and Teaching

Teachers could have student teams research the sources (for example, automobile emissions and coal-burning emissions) and degree of acid precipitation in their local area by collecting various water samples and testing for pH over an extended period of time. Data from this testing should be assembled in appropriate formats to display trends and variations in pH for various locations. Students should work co-operatively with team members to develop and carry out a plan that includes compiling and organizing their data in order to infer patterns or trends in the data.

Students could use Internet sites and e-mail to contact other areas which are associated with acid precipitation. They could use this information and library research to write a balanced (that is, presenting all sides) report on the subject, based on information gathered, which includes reference to causes, possible remedies, and the career potential for people working in this field. Students should defend their position with relevant arguments from different perspectives, and include examples of how society supports and influences science and technology. They should also identify examples where technologies were developed on the basis of scientific understanding.

Physical Science: Chemical Reactions

What are some of the effects of industrialization and associated pollution?

Suggested Assessment Strategies

Many activities can be arranged using co-operative groups. These can be assessed not only for the product (scientific content or skill) but also the process (participation by students in given roles).

Informal/Formal Observation and Presentation
Students could present their research on acid precipitation to the whole class. (118-5)

Journal and Portfolio
Group activity rubrics can be designed (or used) to assess the research projects; students can be asked to report in journals about their research projects; or students can be asked to write a summary of their work for their portfolios. (213-5, 214-5, 215-6)

Paper and Pencil and Presentation
Longer term projects on acid precipitation should be assessed in terms of the quality of the research, preparation, and the final presentation. This presentation can take various forms such as a web-page design, an information flyer or a brochure, a newspaper advertisement or a radio spot. Students should see examples or be following a stated rubric. Assessment should extend beyond science content to include use of language, the manner in which ideas are expressed, and the ways in which different media are used for research and presentation. (117-1, 117-7, 118-5, 213-5, 214-5, 214-15)

Resources