(c) Cr_2O_3
(d) $Cu(NO_3)_2$
(e) $Ca(OH)_2$
(f) $PbSO_4$
(g) $HCl_{(aq)}$
(h) SO_2
(i) CO

GETTING STARTED

TRY THIS ACTIVITY: MAKING MONEY

(Page 373)

(a) $CuSO_{4(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + ZnSO_{4(aq)}$
(b) The procedure is a simple and quick way of coating zinc with copper. However, the copper coating appears rough and does not adhere well to the metal. Furthermore, this procedure consumes zinc, making the zinc strip thinner.

REFLECT ON YOUR LEARNING

(Page 373)

The following are typical student responses.
1. Oxidation is what happens when a substance reacts with oxygen in the air. OR
   Oxidation is what happens when iron reacts with air to form iron oxide.
2. The chemicals inside a battery react to produce electricity.
3. The chemicals inside the battery are returned to their initial form by applying electrical energy.
4. Corrosion is the reaction of a metal with chemicals in the air. Corrosion can be prevented by rustproofing the metal (perhaps by covering it, to prevent it from reacting with other chemicals). OR
   Corrosion is the slow oxidation of a metal.
5. Chemical reactions can, in some cases, be used to produce electricity. Conversely, electricity can be used to make some chemical reactions occur.

5.1 OXIDATION–REDUCTION REACTIONS

CAREER CONNECTION: FILM-PROCESSING TECHNICIAN

(Page 374)

(i) Career #1: Photographer
Creative, technically skilled photographer wanted. The ideal candidate should be familiar with the latest equipment used to take pictures as well as to process them. Experience with the digital enhancement of pictures using state-of-the-art software is definitely an asset. The photographer should be prepared to work irregular hours on location or in the studio to match client schedules. The ideal candidate should have strong interpersonal and time-management skills. Salary ranges from $30 000 to $45 000, depending on experience.

Career #2: Scientific Photographer
A medical graphics company requires a highly skilled scientific photographer immediately. The ideal candidate should be familiar with the use of high-powered lenses and microscopes to create images of biological specimens such as tissue samples, bacteria, and viruses. The successful candidate will be familiar with the latest trends in camera technology and film processing techniques. He/she should also have a strong scientific background in the specific imaging techniques used in cell biology or medical technology. Experience in preparing biological samples for imaging is a definite asset. The ideal candidate should have the strong interpersonal and communication skills required to be an important member of a research team.

(ii) Faster films have increased light sensitivity, resulting from the use of larger silver halide grains in the photographic emulsion. Fast films are ideal for taking photographs in dim lighting conditions without the use of a flash, or of fast-moving objects. However, because the film contains larger silver halide grains, photographs can sometimes turn out "grainy" in appearance. Slower film is ideal for portrait work. The silver halide grains in this film are smaller in size, allowing for better detail in the photographs.

PRACTICE

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	Reactant oxidized	Reactant reduced
(a)	$Ca_{(s)}$	$Sn^{2+}_{(aq)}$
(b)	$Mg_{(s)}$	$Cu^{2+}_{(aq)}$
(c)	$Zn_{(s)}$	$Ag^{+}_{(aq)}$
(d)	$Al_{(s)}$	$Cu^{2+}_{(aq)}$
(e)	$Fe_{(s)}$	$Br_{2(l)}$
(f)	$Ag_{(s)}$	$S_{(s)}$
(g)	$K_{(s)}$	$I_{2(g)}$
(h)	$Al_{(s)}$	$O_{2(g)}$

TRY THIS ACTIVITY: THE POP CAN RIP-OFF

(Page 377)

(a) Small grains of a reddish solid are observed inside the can. The blue colour of the solution is less intense at the end of the activity than at the beginning.
(b) Reactant oxidized: $Al_{(s)}$ Reactant reduced: $Cu^{2+}_{(aq)}$
(c) The plastic lining prevents the contents of the can from possibly reacting with the aluminum.

SECTION 5.1 QUESTIONS

(Pages 377–378)

Understanding Concepts

1. **Table 1** Summary of Oxidation and Reduction

	Electrons gained or lost	Change in charge on the reactant atom/ion
Oxidation	electrons lost	charge becomes more positive
Reduction	electrons gained	charge becomes less positive (more negative)

2.

(a)	K_2O	potassium 1+	oxide 2−
(b)	CaO	calcium 2+	oxide 2−
(c)	Fe_2O_3	iron 3+	oxide 2−
(d)	$Cu(NO_3)_2$	copper 2+	nitrate 1−
(e)	$Al(OH)_3$	aluminum 3+	hydroxide 1−
(f)	$Fe_2(SO_4)_3$	iron 3+	sulfate 2−

3.

	Reactant oxidized	Reactant reduced
(a)	$Ca_{(s)}$	$Cl_{2(g)}$
(b)	$Zn_{(s)}$	$S_{(s)}$
(c)	$Mg_{(s)}$	$Pb^{2+}_{(aq)}$
(d)	$Fe_{(s)}$	$Ag^{+}_{(aq)}$
(e)	$Mg_{(s)}$	$Ni^{2+}_{(aq)}$
(f)	$Fe_{(s)}$	$H^{+}_{(aq)}$
(g)	$Mg_{(s)}$	$Cu^{2+}_{(aq)}$
(h)	$Al_{(s)}$	$Ag^{+}_{(aq)}$

4. The metal is oxidized and the nonmetal is reduced.
5. The number of electrons gained and lost in a redox reaction must be equal because the electrons used to reduce one reactant are produced by the oxidation of the other reactant. In other words, the electrons transfer from one reactant to the other.

Applying Inquiry Skills

6. Because the mass of the paperclip decreased, we can assume that some of the iron in the paperclip was oxidized into ions by the chemicals in the cola.

Making Connections

7. (a) Reactant oxidized: $Al_{(s)}$ Reactant reduced: $Ag^{+}_{(aq)}$ or $Ag_2S_{(s)}$
   (b) Method in (a) is better because it returns silver that was oxidized to the silverware. Although method (b) is effective, a small amount of silver is permanently removed each time the silverware is scrubbed.
8. Photographic film has a solid base, usually made of a plastic such as celluloid or polyester, which is coated with a gel containing light-sensitive silver halide compounds (such as silver bromide, silver chloride, and silver iodide). The energy of the incoming light, particularly from the blue end of the visible spectrum, oxidizes some of the halide ions to halogen atoms:
   $X^{-}_{(aq)}$ + light energy $\rightarrow X_{(s)} + e^{-}$ where X could be Cl, Br, or I.

   Electrons, released by this process, reduce silver ions in the exposed film to grey-black silver atoms, forming a so-called "latent image":
   $Ag^{+}_{(aq)} + e^{-} \rightarrow Ag_{(s)}$

   However, the latent image is too weak to be seen, and requires amplification. This amplification stage is commonly known as "developing," and is done through the action of chemical developers such as hydroquinone, HOC_6H_4OH. The formation of silver atoms in the latent image sensitizes the neighbouring silver halide crystals, making them more susceptible to the action of the developer. When the film is dipped into a bath of developer, silver halide grains next to the latent image are also reduced to silver metal:
   $2\ AgX_{(s)} + HOC_6H_4OH_{(aq)} + 2\ OH^{-}_{(aq)}. \rightarrow 2\ Ag_{(s)} + C_6H_4O_2 + 2\ H_2O_{(l)} + 2\ X^{-}_{(aq)}.$

   The silver atoms produced in this reaction collect around the silver grains of the latent image, making them large enough to be seen. When the photographic image has developed to the desired degree, the developing reaction is "stopped" by dipping the film into an acidic solution such as acetic acid.

Extension

9. (a) The oxidation of glucose is an important biological process that releases a great deal of energy. When plenty of oxygen is available, glucose is oxidized directly into carbon dioxide and water. The energy released in the process is stored in a molecule called adenosine triphosphate or ATP. During strenuous exercise, however, sufficient oxygen may not be available. Under these conditions, glucose is oxidized into lactic acid.
   (b) Muscles used in long-distance running rely more on aerobic oxidation of glucose for their energy. When running at a comfortable pace, both systems of oxidation are used but the ratio of anaerobic: aerobic is low enough to prevent lactic acid from accumulating. As the pace increases, the anaerobic: aerobic ratio increases to the point where lactic acid begins to accumulate in the blood. This is known as the lactic acid threshold. In order to improve performance, long-distance runners try to train at the speed at which the lactic acid threshold occurs. This serves to increase the threshold and overall performance.

5.2 REDOX REACTIONS OF NONMETALS

PRACTICE

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1.

(a)	Cl	0		
(b)	S	0		
(c)	H	+1	S	−2
(d)	F	−1		
(e)	Na	+1	O	−2
(f)	C	+4	O	−2
(g)	Fe	+3	O	−2
(h)	H	+1	O	−1

2.

(a)	Cl	+3
(b)	N	+3
(c)	S	+4
(d)	C	+4
(e)	Cl	+7
(f)	Fe	+3
(g)	Pb	+2
(h)	Mn	+7