5.4 THE ACTIVITY SERIES OF METALS

PRACTICE

(Page 388)

(a) $Zn_{(s)} + 2\ AgNO_{3(aq)} \rightarrow 2\ Ag_{(s)} + Zn(NO_3)_{2(aq)}$
(b) $Cu_{(s)} + SnCl_{2(aq)} \rightarrow$ no reaction
(c) $Mg_{(s)} + HNO_{3(aq)} \rightarrow H_{2(g)} + Mg(NO_3)_{2(aq)}$ OR
$Mg_{(s)} + 2\ NO^{-}_{3(aq)} + 4\ H^{+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + 2\ H_2O_{(l)} + N_2O_{(g)}$
(d) $Ag_{(s)} + H_2SO_{4(aq)} \rightarrow$ no reaction
(e) $Zn_{(s)} + FeSO_{4(aq)} \rightarrow Fe_{(s)} + ZnSO_{4(aq)}$

TRY THIS ACTIVITY: COKE CORROSION

(Page 389)

(a) Stomach acid should corrode the nail faster, since it is more acidic.
(b) **Observed mass changes in HCl**

Paperclip before:	1.558 g
Paperclip after two days in HCl:	1.520 g
Mass change:	0.038 g

Observed mass changes in Coke

Paperclip before:	1.535 g
Paperclip after two days in Coke:	1.534 g
Mass change:	0.001 g

(c) The paperclip stored in hydrochloric acid decreased noticeably in mass, while the paperclip stored in Coke did not. This observation is consistent with the fact that the stomach acid solution is significantly more acidic than Coke.
(d) The stomach is specifically designed to withstand the corrosive effects of its own fluids that, as stated in the introduction, are significantly more acidic than Coke. Therefore, consuming Coke should not aggravate a “healthy” stomach. In fact, Coke would slightly dilute stomach acid.
(e) A nail stored in Coke for a long time may decrease slightly in mass. However, for all practical purposes, Coke will not dissolve (oxidize) an iron nail.

SECTION 5.4 QUESTIONS

(Pages 389–390)

Understanding Concepts

1. The metals in the activity series are arranged in order of their reactivity. The most reactive metals (metals with the greatest tendency to be oxidized) are at the top of the series. The least reactive metals (metals with the least tendency to be oxidized) are at the bottom.
2. Hydrogen is included in the activity series because, like metals, it forms positive ions.
3. (a) $Zn_{(s)} + Cu(NO_3)_{2(aq)} \rightarrow Cu_{(s)} + Zn(NO_3)_{2(aq)}$
   (b) $Au_{(s)} + FeSO_{4(aq)} \rightarrow$ no reaction
   (c) $Zn_{(s)} + 2\ HCl_{(aq)} \rightarrow H_{2(g)} + ZnCl_{2(aq)}$
   (d) $Pb_{(s)} + Ni(NO_3)_{2(aq)} \rightarrow$ no reaction
   (e) $Mg_{(s)} + H_2SO_{4(aq)} \rightarrow H_{2(g)} + MgSO_{4(aq)}$
4. Since gold is at the bottom of the activity series, we know that gold is unreactive (difficult to oxidize). The metals above gold oxidize more readily, forming metal ions that combine with negative ions (anions) to form compounds.

Applying Inquiry Skills

5. Silver should show no evidence of reactivity in hydrochloric acid. All the other silvery-gray metals should react in $HCl_{(aq)}$ to release bubbles of hydrogen gas.
6. (a) Since nickel is above hydrogen on the activity series, it is expected that nickel will corrode in an acid solution like perspiration.
   (b) Since titanium displayed less reactivity with acid compared to nickel, it can be assumed, based on the information given, that titanium is below nickel on the activity series.

(c) The thin coating of titanium oxide isolates titanium atoms from their environment, preventing the titanium from corroding further.

7. **Table 1** Predictions for Reactions Between Metals and Their Ions

Metal \ Ion	$Ag^{+}_{(aq)}$	$Pb^{2+}_{(aq)}$	$Ni^{2+}_{(aq)}$	$Zn^{2+}_{(aq)}$)
$Ag_{(s)}$	NR	NR	NR	NR
$Pb_{(s)}$	R	NR	NR	NR
$Ni_{(s)}$	R	R	NR	NR
$Zn_{(s)}$	R	R	R	NR

NR = no reaction; R = reaction

8. (a) Steel wool is added to the copper(II) sulfate solution and allowed to react. Grains of copper metal are observed to form on the steel wool. Once the blue colour of the solution has completely disappeared, it is safe to assume that most of the copper(II) ions have been converted to copper atoms. The mixture then is filtered to separate the remaining solids from the solution.
   (b) $CuSO_{4(aq)} + Fe_{(s)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$
   (c) The copper ions could also be removed from the solution by precipitating them with a carbonate solution such as sodium carbonate. The solubility table (Appendix D4) suggests that copper(II) carbonate is insoluble in water and, as a result, should precipitate.
   (d) Student answers will vary. Removing copper(II) ions using steel wool is more effective because the solids left over at the end of the process are large enough to be filtered easily. Precipitation reactions, like the addition of sodium carbonate to copper(II) sulfate, often produce very fine precipitates that quickly clog the filter paper, making the separation cumbersome. Furthermore, steel wool is easier to obtain than is a compound to precipitate copper(II) ions.

Making Connections

9. (a) $2\ Al_{(s)} + Fe_2O_{3(s)} \rightarrow 2\ Fe_{(s)} + Al_2O_{3(s)}$
   (b) Student answers may vary. http://www.ilpi.com/genchem/demo/thermite/#demo
   (c) The Thermite process has been used to weld sections of railroad track together.

Extension

10. **Analysis**
   (a) The activity series of the three halogens is
   chlorine (most reactive)
   bromine
   iodine (least reactive)
   (b) Fluorine should be at the top of the halogen activity series since the observed reactivity of the other halogens follows the order of the halogens in the periodic table.

5.5 INVESTIGATION: TESTING THE ACTIVITY SERIES

(Pages 391–392)

Prediction

(a) According to the activity series, the following combinations of metals and solutions should react:
$Mg_{(s)}$ with $AgNO_{3(aq)}$
$Mg_{(s)}$ with $CuSO_{4(aq)}$
$Mg_{(s)}$ with $FeSO_{4(aq)}$
$Mg_{(s)}$ with $ZnSO_{4(aq)}$

$Zn_{(s)}$ with $AgNO_{3(aq)}$
$Zn_{(s)}$ with $CuSO_{4(aq)}$
$Zn_{(s)}$ with $FeSO_{4(aq)}$

$Fe_{(s)}$ with $AgNO_{3(aq)}$