The activity series and electricity

Metal and metal ions compete for electrons and cause chemical reactions to occur. For instance, since zinc is more active than copper it will become oxidized in a copper solution and the copper ions will become reduced. The two half-reactions are as follows:

$$Zn^0 \longrightarrow Zn^{2+} + 2e^- \qquad (1)$$
$$Cu^{2+} + 2e^- \longrightarrow Cu^0 \qquad (2)$$

The two half-reactions or electron transfer reactions occur at the surface of the zinc strip. If the two half-reactions are separated, the electrons will travel through a wire and produce an electric current. In this activity you will make electricity and learn the parts of an **electrochemical cell.**

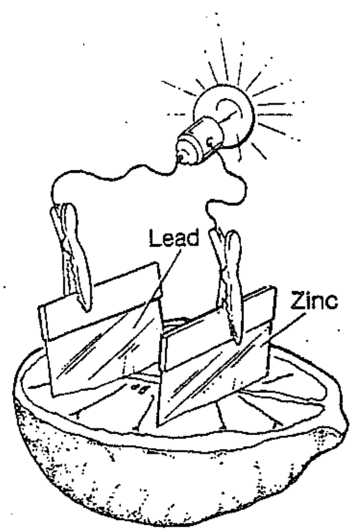

Fig. 11.8

Material

- voltmeter 0-3 v
- 1.5 v light bulb
- miniature socket
- wire connectors with alligator clips
- 250 mL beakers (3)
- glass wool
- glass U-tube
- emery paper
- lemon
- lead strip
- zinc strip
- copper(II) nitrate solution
- zinc nitrate solution
- copper strip
- potassium nitrate solution
- lead nitrate solution

Method

1. Push a strip of lead and a strip of zinc into a lemon.
2. Place the light bulb in the socket and connect the wires to the terminals of the socket.
3. Connect the alligator clips to the metal strips as shown in Figure 11.8. Record your observations.
4. Remove the socket and replace it with a voltmeter. Reconnect the wires to the voltmeter as shown. Observe and record the voltage for each cell formed. Note which way the needle moves. This shows the flow of electrons.
5. Switch the wire connections to the voltmeter. Note any change in the voltmeter.
6. Use different combinations of electrodes. Each time, note the direction in which the needle moves. This shows the direction of electron flow.
7. Put 150 mL of copper(II) nitrate solution into one beaker and 150 mL of zinc nitrate solution into the other.
8. Place a clean copper strip into the copper(II) nitrate solution and a clean zinc strip into the zinc nitrate solution.
9. Use the wire connectors to connect the metal strips to the voltmeter. Record your observations.
10. Fill the U-tube with potassium nitrate solution and put glass wool into each end as a plug. Use the U-tube to make a bridge as shown in Figure 11.9.
11. Watch the voltmeter. Record your observations. Note the direction of flow of electrons.
12. Repeat steps 8, 9, and 11 using the lead nitrate and zinc nitrate solutions and strips, then copper(II) nitrate and lead nitrate solutions and strips.
13. Note the direction of electron flow in each case.

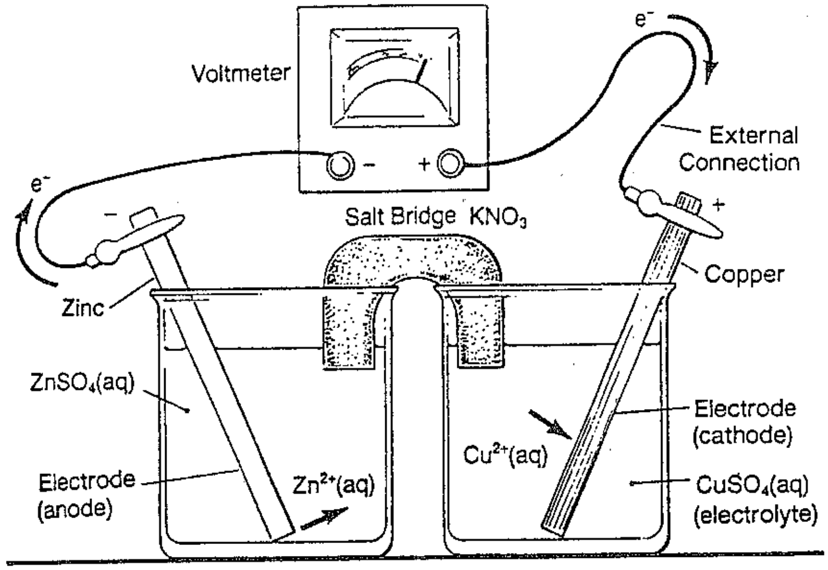

Fig. 11.9 The parts of an electrochemical cell

ACTIVITY SERIES

Li
K
Ca
Na
Mg
Al
Zn
Cr
Fe
Ni
Sn
Pb
H_2
Cu
Hg
Ag

Questions and Conclusions

1. a. Which way were electrons flowing in the zinc and copper cell?
   b. Which substance was being oxidized? Reduced?
   c. Write each half-reaction.
2. Which combination gives the highest voltage?
   a. lead and zinc b. lead and copper c. zinc and copper
3. Compare the positions of the metals in the activity series with the voltages noted in your answer to question 2. Is there a relationship?
4. a. Does the cell work without the glass U-tube?
   b. What is the U-tube's purpose?
5. What are the main parts of an electrochemical cell?

Table 1 Standard Electrode Potentials

Electrode reaction	$E°$(V)	Electrode reaction	$E°$(V)
$Li^+(aq) + e^- \rightleftarrows Li(s)$	−3.0401	$Cu^{2+}(aq) + 2e^- \rightleftarrows Cu(s)$	+0.3419
$K^+(aq) + e^- \rightleftarrows K(s)$	−2.931	$O_2(g) + 2H_2O(l) + 4e^- \rightleftarrows 4OH^-(aq)$	+0.401
$Na^+(aq) + e^- \rightleftarrows Na(s)$	−2.71	$I_2(s) + 2e^- \rightleftarrows 2I^-(aq)$	+0.5355
$2H_2O(l) + 2e^- \rightleftarrows H_2(g) + 2OH^-(aq)$	−0.828	$Fe^{3+}(aq) + e^- \rightleftarrows Fe^{2+}(aq)$	+0.771
$Zn^{2+}(aq) + 2e^- \rightleftarrows Zn(s)$	−0.7618	$Hg_2^{2+}(aq) + 2e^- \rightleftarrows 2Hg(l)$	+0.7973
$Fe^{2+}(aq) + 2e^- \rightleftarrows Fe(s)$	−0.447	$Ag^+(aq) + e^- \rightleftarrows Ag(s)$	+0.7996
$PbSO_4(s) + H_3O^+(aq) + 2e^- \rightleftarrows Pb(s) + HSO_4^-(aq) + H_2O(l)$	−0.42	$Br_2(l) + 2e^- \rightleftarrows 2Br^-(aq)$	+1.066
$Cd^{2+}(aq) + 2e^- \rightleftarrows Cd(s)$	−0.4030	$Cl_2(g) + 2e^- \rightleftarrows 2Cl^-(aq)$	+1.358
$Pb^{2+}(aq) + 2e^- \rightleftarrows Pb(s)$	−0.1262	$PbO_2(s) + 4H_3O^+(aq) + 2e^- \rightleftarrows Pb^{2+}(aq) + 6H_2O(l)$	+1.455
$Fe^{3+}(aq) + 3e^- \rightleftarrows Fe(s)$	−0.037	$PbO_2(s) + HSO_4^-(aq) + 3H_3O^+(aq) + 2e^- \rightleftarrows PbSO_4(s) + 5H_2O(l)$	+1.691
$2H_3O^+(aq) + 2e^- \rightleftarrows H_2(g) + 2H_2O(l)$	0.0000	$Ce^{4+}(aq) + e^- \rightleftarrows Ce^{3+}(aq)$	+1.72
$AgCl(s) + e^- \rightleftarrows Ag(s) + Cl^-(aq)$	+0.222	$F_2(g) + 2e^- \rightleftarrows 2F^-(aq)$	+2.866

Refer to Appendix A for additional standard electrode potentials.