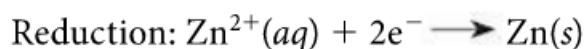
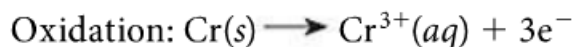


## Lesson Check Answers

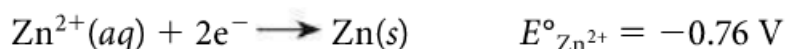
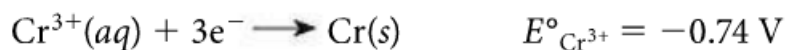
- a redox reaction
- spontaneous redox reactions within the cell
- fuel cells, lead storage batteries, and dry cells
- calcium
- concentrated sulfuric acid;  
Anode:  
 $\text{Pb}(s) + \text{SO}_4^{2-}(aq) \rightarrow \text{PbSO}_4(s) + 2e^-$   
Cathode:  
 $\text{PbO}_2(s) + 4\text{H}^+(aq) + \text{SO}_4^{2-}(aq) + 2e^- \rightarrow \text{PbSO}_4(s) + 2\text{H}_2\text{O}(l)$
- $2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(l)$ ; water is the product.  $\text{H}_2$  is oxidized at the anode;  $\text{O}_2$  is reduced at the cathode.
- no reaction

## Sample Problems

- 8.** The half-reactions are



Writing both half-cells as reductions:



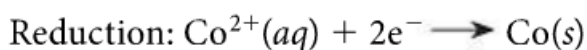
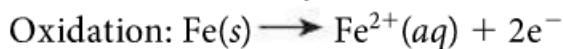
$$E^\circ_{\text{cell}} = E^\circ_{\text{red}} - E^\circ_{\text{oxid}} = E^\circ_{\text{Zn}^{2+}} - E^\circ_{\text{Cr}^{3+}}$$

$$= -0.76 \text{ V} - (-0.74 \text{ V}) = -0.02 \text{ V}$$

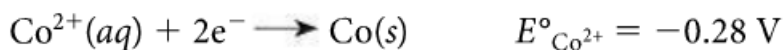
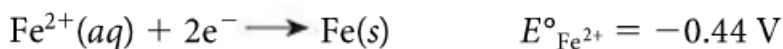
$E^\circ_{\text{cell}} < 0$ , so the reaction is not spontaneous.

Another way to calculate:  $E^\circ_{\text{cell}} = E^\circ_{\text{SRP}} + E^\circ_{\text{SOP}} \dots$  negate the oxidation SRP.  $E^\circ_{\text{cell}} = E^\circ_{\text{SRP}(\text{Zn})} + E^\circ_{\text{SOP}(\text{Cr})} = -0.76 \text{ V} + 0.74 \text{ V} = -0.02 \text{ V}$

**9.** The half-reactions are



Writing both half-cells as reductions:



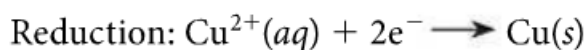
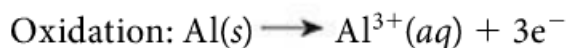
$$E^{\circ}_{\text{cell}} = E^{\circ}_{\text{red}} - E^{\circ}_{\text{oxid}} = E^{\circ}_{\text{Co}^{2+}} - E^{\circ}_{\text{Fe}^{2+}}$$

$$= -0.28 \text{ V} - (-0.44 \text{ V}) = +0.16 \text{ V}$$

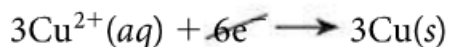
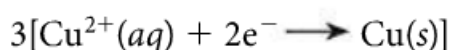
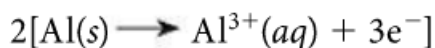
$E^{\circ}_{\text{cell}} > 0$ , so the reaction is spontaneous.

Another way to calculate:  $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{SRP}} + E^{\circ}_{\text{SOP}} \dots$  negate the oxidation SRP.  $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{SRP}(\text{Co})} + E^{\circ}_{\text{SOP}(\text{Fe})} = -0.28 \text{ V} + 0.44 \text{ V} = +0.16 \text{ V}$

**10.**  $\text{Cu}^{2+}$  is reduced, and Al is oxidized.

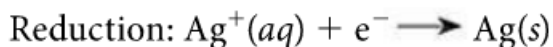
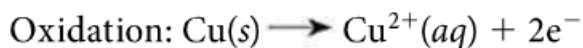


Writing both half-cells as reductions:

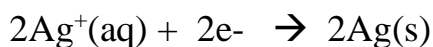
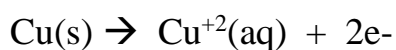
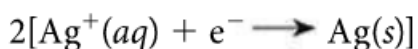
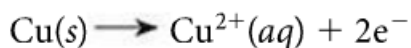


**11.**  $\text{Ag}^+$  is reduced, and Cu is oxidized.

The half-reactions are



Writing both half-cells as reductions:



*Notice that copper is oxidized (because it is the more active metal) and will reduce the silver.*

**12.**  $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{red}} - E^{\circ}_{\text{oxid}} = E^{\circ}_{\text{Cu}^{2+}} - E^{\circ}_{\text{Al}^{3+}}$   
 $= 0.34 \text{ V} - (-1.66 \text{ V}) = +2.00 \text{ V}$

Another way to calculate:  $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{SRP}} + E^{\circ}_{\text{SOP}}$  ... negate the oxidation SRP.  $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{SRP}(\text{Cu})} + E^{\circ}_{\text{SOP}(\text{Al})} = +0.34 \text{ V} + 1.66 \text{ V} = +2.00 \text{ V}$

*Aluminum is a more active metal than copper so aluminum will be oxidized and will reduce the copper.*

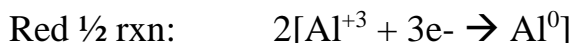
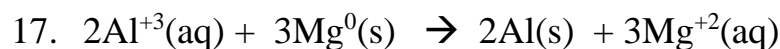
**13.**  $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{red}} - E^{\circ}_{\text{oxid}} = E^{\circ}_{\text{Ag}^+} - E^{\circ}_{\text{Cu}^{2+}}$   
 $= 0.80 \text{ V} - (+0.34 \text{ V}) = +0.46 \text{ V}$

Another way to calculate:  $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{SRP}} + E^{\circ}_{\text{SOP}}$  ... negate the oxidation SRP.  $E^{\circ}_{\text{cell}} = E^{\circ}_{\text{SRP}(\text{Ag})} + E^{\circ}_{\text{SOP}(\text{Cu})} = +0.80 \text{ V} - 0.34 \text{ V} = +0.46 \text{ V}$

*Copper is a more active metal than silver so copper will be oxidized and will reduce the silver.*

## Lesson Check Answers

14. Electrical potential of cell results from competition for electrons between two half-cells.
15. by connecting it to a standard hydrogen electrode and measuring the cell potential
16. If the cell potential for a redox reaction is positive, the reaction is spontaneous; if it is negative, the reaction is nonspontaneous.
17. spontaneous;  $E_{\text{cell}}^{\circ} = +0.71 \text{ V}$
18.  $2\text{Li}(s) + \text{Mg}^{2+}(\text{aq}) \rightarrow \text{Mg}(s) + 2\text{Li}^{+}(\text{aq});$   
 $E_{\text{cell}}^{\circ} = +0.68$
19. There is an positive electrical potential between the negative and positive terminals of the battery.  
 Cell reaction:  
 $\text{Pb} + \text{PbO}_2 + 2\text{H}_2\text{SO}_4^{2-} \rightarrow$   
 $2\text{PbSO}_4 + 2\text{H}_2\text{O}; E_{\text{cell}}^{\circ} = +2.05 \text{ V}$

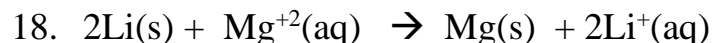


$E_{\text{cell}}^0 = E_{\text{SRP}}^0 + E_{\text{SOP}}^0 \dots$  negate the oxidation SRP.

$$E_{\text{cell}}^0 = E_{\text{SRP (Al)}}^0 + E_{\text{SOP (Mg)}}^0 = +2.37 \text{ V} + (-1.66 \text{ V}) = +0.71 \text{ V}$$

This is a spontaneous reaction.

*Magnesium is a more active metal than Aluminum so magnesium will be oxidized and will reduce the aluminum.*



$E_{\text{cell}}^0 = E_{\text{SRP}}^0 + E_{\text{SOP}}^0 \dots$  negate the oxidation SRP.

$$E_{\text{cell}}^0 = E_{\text{SRP (Mg)}}^0 + E_{\text{SOP (Li)}}^0 = -2.37 \text{ V} + 3.05 \text{ V} = +0.68 \text{ V}$$

This is a spontaneous reaction.

*Lithium is a more active metal than magnesium so lithium will be oxidized and will reduce the magnesium.*

- 20.** A voltaic cell uses an electrochemical reaction to produce electrical energy; an electrolytic cell uses electrical energy to bring about a chemical change.
- 21.** to separate elements from compounds and to plate, purify, and refine metals
- 22.** electrolytic cell anode (+); voltaic cell anode (-)
- 23.** Reduction always occurs at the cathode.
- 24.** Anode:  $\text{C}(s) + 2\text{O}^{2-}(l) \rightarrow \text{CO}_2(g) + 4e^-$   
Cathode:  $3e^- + \text{Al}^{3+}(l) \rightarrow \text{Al}(l)$   
Adding cryolite to aluminum oxide results in a mixture that melts at a much lower temperature ( $1012^\circ\text{C}$ ) than pure aluminum oxide ( $2045^\circ\text{C}$ ).
- 25.** Yes, the electrical energy produced in a voltaic cell can do work. An electrolytic cell does not produce free energy unless an electrical current is supplied.