10.3 STOICHIOMETRY OF CELL REACTIONS

PRACTICE

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Understanding Concepts

1. $I = 1.5\ \text{A} = 1.5\ \text{C/s}$
   $t = 30\ \text{s}$

$$\begin{aligned} q &= It \\ &= 1.5\ \frac{\text{C}}{\cancel{\text{s}}} \times 30\ \cancel{\text{s}} \\ q &= 45\ \text{C} \end{aligned}$$

   The charge transferred is 45 C.

2. $q = 87.6\ \text{C}$
   $t = 22.5\ \text{s}$

$$\begin{aligned} q &= It \\ I &= \frac{q}{t} \\ &= \frac{87.6\ \text{C}}{22.5\ \text{s}} \\ &= 3.89\ \text{C/s} \\ I &= 3.89\ \text{A} \end{aligned}$$

   The average electric current is 3.89 A.

3. $I = 250\ \text{mA} = 250 \times 10^{-3}\ \text{C/s}$
   $t = 28.5\ \text{s}$

$$\begin{aligned} q &= It \\ &= 250 \times 10^{-3}\ \frac{\text{C}}{\cancel{\text{s}}} \times 28.5\ \cancel{\text{s}} \\ q &= 7.13\ \text{C} \end{aligned}$$

   The charge transferred is 7.13 C.

4. $I = 1.60\ \text{A} = 1.60\ \text{C/s}$
   $q = 375\ \text{C}$

$$\begin{aligned} q &= It \\ t &= \frac{q}{I} \\ &= \frac{375\ \cancel{\text{C}}}{1.60\ \frac{\cancel{\text{C}}}{\text{s}}} \\ &= 234\ \text{s} \\ &= 234\ \cancel{\text{s}} \times \frac{1\ \text{min}}{60\ \cancel{\text{s}}} \\ t &= 3.91\ \text{min} \end{aligned}$$

   The charge is transferred in a time of 3.91 min.

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Understanding Concepts

5. $I = 1.9 \text{ A} = 1.9 \text{ C/s}$

$t = 35 \cancel{\text{min}} \times \dfrac{60 \text{ s}}{1 \cancel{\text{min}}} = 2.1 \times 10^3 \text{ s}$

$F = 9.65 \times 10^4 \text{ C/mol}$

$$n_{e^-} = \frac{q}{F}$$

$$= \frac{It}{F}$$

$$= \frac{1.9 \dfrac{\cancel{\text{C}}}{\cancel{\text{s}}} \times 2.1 \times 10^3 \cancel{\text{s}}}{9.65 \times 10^4 \dfrac{\cancel{\text{C}}}{\text{mol}}}$$

$$n_{e^-} = 0.041 \text{ mol} = 41 \text{ mmol}$$

The amount of electrons transferred is 0.041 mol or 41 mmol.

6. $I = 1.24 \text{ A} = 1.24 \text{ C/s}$

$n_{e^-} = 0.146 \text{ mol}$

$F = 9.65 \times 10^4 \text{ C/mol}$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$t = \frac{n_{e^-}F}{I}$$

$$= \frac{0.146 \cancel{\text{mol}} \times 9.65 \times 10^4 \dfrac{\cancel{\text{C}}}{\cancel{\text{mol}}}}{1.24 \dfrac{\cancel{\text{C}}}{\text{s}}}$$

$$t = 1.13 \times 10^4 \cancel{\text{s}} \times \frac{1 \text{ h}}{3600 \cancel{\text{s}}} = 3.16 \text{ h}$$

The time of cell operation is 3.16 h.

7. $t = 20 \cancel{\text{min}} \times \dfrac{60 \text{ s}}{1 \cancel{\text{min}}} = 1.2 \times 10^3 \text{ s}$

$n_{e^-} = 0.015 \text{ mol}$

$F = 9.65 \times 10^4 \text{ C/mol}$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$I = \frac{n_{e^-}F}{t}$$

$$= \frac{0.015 \cancel{\text{mol}} \times 9.65 \times 10^4 \dfrac{\text{C}}{\cancel{\text{mol}}}}{1.2 \times 10^3 \text{ s}}$$

$$I = 1.2 \text{ C/s} = 1.2 \text{ A}$$

The current required is 1.2 A.

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Understanding Concepts

8. $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2\ e^-$

m, 65.38 g/mol; 0.500 A, 10.0 min, 9.65×10^4 C/mol

$$I = 0.500\ \text{A} = 0.500\ \text{C/s}$$

$$t = 10.0\ \cancel{\text{min}} \times \frac{60\ \text{s}}{1\ \cancel{\text{min}}} = 600\ \text{s}$$

$$n_{e^-} = \frac{q}{F}$$

$$= \frac{It}{F}$$

$$= \frac{0.500\ \frac{\cancel{\text{C}}}{\cancel{\text{s}}} \times 600\ \cancel{\text{s}}}{9.65 \times 10^4\ \frac{\cancel{\text{C}}}{\text{mol}}}$$

$$n_{e^-} = 0.00311\ \text{mol}$$

$$n_{Zn} = 0.00311\ \cancel{\text{mol}}\ e^- \times \frac{1\ \text{mol Zn}}{2\ \cancel{\text{mol}}\ e^-}$$

$$n_{Zn} = 0.00155\ \text{mol}$$

$$m_{Zn} = 0.00155\ \cancel{\text{mol}} \times 65.38\ \frac{\text{g}}{\cancel{\text{mol}}}$$

$$m_{Zn} = 0.102\ \text{g}$$

The mass of zinc oxidized is 0.102 g.

9. (a) $Cr^{3+}_{(aq)} + 3\ e^- \rightarrow Cr_{(s)}$

54 A, 45 min 30 s, 9.65×10^4 C/mol; m, 52.00 g/mol

$$I = 54\ \text{A} = 54\ \text{C/s}$$

$$t = 45\ \cancel{\text{min}} \times \frac{60\ \text{s}}{1\ \cancel{\text{min}}} + 30\ \text{s}$$

$$= 2700\ \text{s} + 30\ \text{s}$$

$$t = 2730\ \text{s}$$

Note: Because time was measured to a precision of seconds, this time value (2730 s) has a certainty of 4 significant digits.

$$n_{e^-} = \frac{q}{F}$$

$$= \frac{It}{F}$$

$$= \frac{54\ \frac{\cancel{\text{C}}}{\cancel{\text{s}}} \times 2730\ \cancel{\text{s}}}{9.65 \times 10^4\ \frac{\cancel{\text{C}}}{\text{mol}}}$$

$$n_{e^-} = 1.5\ \text{mol}$$

$$n_{Cr} = 1.5\ \cancel{\text{mol}}\ e^- \times \frac{1\ \text{mol Cr}}{3\ \cancel{\text{mol}}\ e^-}$$

$$n_{Cr} = 0.51\ \text{mol}$$

$$m_{Cr} = 0.51\ \cancel{mol} \times 52.00\ \frac{g}{\cancel{mol}}$$
$$m_{Cr} = 26\ g$$

The mass of chromium produced is 26 g.

(b) $Ni^{2+}_{(aq)} + 2\,e^- \rightarrow Ni_{(s)}$

	0.540 A	0.250 g
	9.65×10^4 C/mol	58.69 g/mol
	t	

$$I = 0.540\ A = 0.540\ C/s$$
$$n_{Ni} = 0.250\ \cancel{g} \times \frac{1\ mol}{58.69\ \cancel{g}}$$
$$n_{Ni} = 0.00426\ mol$$
$$n_{e^-} = 0.00426\ \cancel{mol\ Ni} \times \frac{2\ mol\ e^-}{1\ \cancel{mol\ Ni}}$$
$$n_{e^-} = 0.00852\ mol$$
$$n_{e^-} = \frac{q}{F}$$
$$n_{e^-} = \frac{It}{F}$$
$$t = \frac{n_{e^-}F}{I}$$
$$= \frac{0.00852\ \cancel{mol} \times 9.65 \times 10^4\ \frac{\cancel{C}}{\cancel{mol}}}{0.540\ \frac{\cancel{C}}{s}}$$
$$t = 1.52 \times 10^3\ \cancel{s} \times \frac{1\ min}{60\ \cancel{s}}$$
$$t = 25.4\ min$$

The time to plate the nickel is 25.4 min.

10. (cathode) $2\,[Al^{3+}_{(l)} + 3\,e^- \rightarrow Al_{(s)}]$

(anode) $3\,[2\,Cl^-_{(l)} \rightarrow Cl_{2(g)} + 2\,e^-]$

(net) $2\,Al^{3+}_{(l)} + 6\,Cl^-_{(l)} \rightarrow 2\,Al_{(s)} + 3\,Cl_{2(g)}$

	5.40 g	m
	26.98 g/mol	70.90 g/mol

$$n_{Al} = 5.40\ \cancel{g} \times \frac{1\ mol}{26.98\ \cancel{g}}$$
$$n_{Al} = 0.200\ mol$$
$$n_{Cl_2} = 0.200\ \cancel{mol\ Al} \times \frac{3\ mol\ Cl_2}{2\ \cancel{mol\ Al}}$$
$$n_{Cl_2} = 0300\ mol$$
$$m_{Cl_2} = 0300\ \cancel{mol} \times 70.90\ \frac{g}{\cancel{mol}}$$
$$m_{Cl_2} = 21.3\ g$$

The mass of chlorine gas produced at the anode is 21.3 g.

11. $Cr_2O^{2-}_{7(aq)} + 14\,H^+_{(aq)} + 12\,e^- \rightarrow 2\,Cr_{(s)} + 7\,H_2O_{(l)}$

	2.20 h	17.8 g
	9.65×10^4 C/mol	52.00 g/mol
	I	

$$t = 2.20\ \cancel{h} \times \frac{3600\ s}{1\ \cancel{h}}$$

$$t = 7.92 \times 10^3\ s$$

$$n_{Cr} = 17.8\ \cancel{g} \times \frac{1\ mol}{52.00\ \cancel{g}}$$

$$n_{Cr} = 0.342\ mol$$

$$n_{e^-} = 0.342\ \cancel{mol\ Cr} \times \frac{12\ mol\ e^-}{2\ \cancel{mol\ Cr}}$$

$$n_{e^-} = 2.05\ mol$$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$I = \frac{n_{e^-}F}{t}$$

$$= \frac{2.05\ \cancel{mol} \times 9.65 \times 10^4\ \frac{C}{\cancel{mol}}}{7.92 \times 10^3\ s}$$

$$I = 25.0\ C/s = 25.0\ A$$

The current required is 25.0 A.

Applying Inquiry Skills

Prediction

12. (a) According to the stoichiometry of the known half-reaction and Faraday's law, 0.766 g of tin should form as shown below.

$Sn^{2+}_{(aq)}$	+	$2\ e^-$	$\rightarrow$	$Sn_{(s)}$
		3.46 A		m
		6.00 min		118.69 g/mol
		9.65×10^4 C/mol		

$$I = 3.46\ A = 3.46\ C/s$$

$$t = 6.00\ \cancel{min} \times \frac{60\ s}{1\ \cancel{min}} = 360\ s$$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$= \frac{3.46\ \frac{\cancel{C}}{\cancel{s}} \times 360\ \cancel{s}}{9.65 \times 10^4\ \frac{\cancel{C}}{mol}}$$

$$n_{e^-} = 0.0129\ mol$$

$$n_{Sn} = 0.0129\ \cancel{mol\ e^-} \times \frac{1\ mol\ Sn}{2\ \cancel{mol\ e^-}}$$

$$n_{Sn} = 0.00645\ mol$$

$$m_{Sn} = 0.00645\ \cancel{mol} \times 118.69\ \frac{g}{\cancel{mol}}$$

$$m_{Sn} = 0.766\ g$$

Analysis

(b) The mass of tin produced is $(118.05 - 117.34)\ g = 0.71\ g$.

Evaluation

(c) $$\% \text{ difference} = \frac{|\text{experimental value} - \text{predicted value}|}{\text{predicted value}} \times 100\%$$

$$= \frac{|0.71 \text{ g} - 0.766 \text{ g}|}{0.766 \text{ g}} \times 100\%$$

$$= \frac{0.06 \cancel{\text{g}}}{0.766 \cancel{\text{g}}} \times 100\%$$

% difference = 7%

The percentage difference in this experimental result is 7%.

(The percentage difference is properly obtained by not rounding any numbers in any of the calculations. If rounded values from previous steps are used, a slightly different percentage will be obtained. Note that the subtraction of two very close values in the % difference produces only one significant digit in the answer.)

(d) The prediction is judged to be verified because its value agrees fairly well with the experimental value; and the difference can be accounted for by typical experimental errors or uncertainties. The stoichiometric method based on the tin half-reaction is judged acceptable because the prediction was verified.

Making Connections

13. (a) A car battery ampere-hour rating tells you how much total charge the battery can deliver, which is proportional to the quantity of energy the battery can provide.

I = 125 A = 125 C/s

t = 1 h = 3600 s

$$q = It$$

$$= 125 \frac{\text{C}}{\cancel{\text{s}}} \times 3600 \cancel{\text{s}}$$

$$q = 4.50 \times 10^5 \text{ C}$$

The maximum charge that can be transferred by this battery is 4.50×10^5 C.

(b) This is a useful way to rate batteries because cost can then be compared to how much energy a battery will supply, allowing an informed choice to be made.

(c) $Pb_{(s)} \rightarrow Pb^{2+}_{(aq)} + 2 e^-$

$Pb_{(s)}$	$\rightarrow$ $Pb^{2+}_{(aq)}$	+	$2 e^-$
m			125 A
207.20 g/mol			1 h = 3600 s
			9.65×10^4 C/mol

I = 125 A = 125 C/s

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$= \frac{125 \frac{\cancel{\text{C}}}{\cancel{\text{s}}} \times 3600 \cancel{\text{s}}}{9.65 \times 10^4 \frac{\cancel{\text{C}}}{\text{mol}}}$$

$$n_{e^-} = 4.66 \text{ mol}$$

$$n_{Pb} = 4.66 \cancel{\text{mol e}^-} \times \frac{1 \text{ mol Pb}}{2 \cancel{\text{mol e}^-}}$$

$$n_{Pb} = 2.33 \text{ mol}$$

$$m_{Pb} = 2.33 \cancel{\text{mol}} \times 207.20 \frac{\text{g}}{\cancel{\text{mol}}}$$

$$m_{Pb} = 483 \text{ g}$$

The mass of lead oxidized as the battery discharges is 483 g.

(d) $Al^{3+}_{(aq)} \quad + \quad 3\ e^- \quad \rightarrow \quad Al_{(s)}$

26.98 g/mol

$$n_{e^-} = 4.66 \text{ mol}$$
$$n_{Al} = 4.66 \cancel{\text{mol}\ e^-} \times \frac{1 \text{ mol Al}}{3 \cancel{\text{mol}\ e^-}}$$
$$n_{Al} = 1.55 \text{ mol}$$
$$m_{Al} = 1.55 \cancel{\text{mol}} \times 26.98 \frac{\text{g}}{\cancel{\text{mol}}}$$
$$m_{Al} = 41.9 \text{ g}$$

The mass of aluminum oxidized would be 41.9 g.

(e) Obviously, there would be a huge weight advantage to using an aluminum–oxygen fuel cell; the mass of metal required for discharge is less than 9% as much, if the charge delivered is equal.

SECTION 10.3 QUESTIONS

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Understanding Concepts

1. $I = 0.300 \text{ A} = 0.300 \text{ C/s}$

$$t = 15.0 \cancel{\text{min}} \times \frac{60 \text{ s}}{1 \cancel{\text{min}}} = 900 \text{ s}$$
$$F = 9.65 \times 10^4 \text{ C/mol}$$
$$n_{e^-} = \frac{q}{F}$$
$$= \frac{It}{F}$$
$$= \frac{0.300 \frac{\cancel{\text{C}}}{\cancel{\text{s}}} \times 900 \cancel{\text{s}}}{9.65 \times 10^4 \frac{\cancel{\text{C}}}{\text{mol}}}$$
$$n_{e^-} = 0.00280 \text{ mol} = 2.80 \text{ mmol}$$

The amount of electrons transferred is 2.80 mmol.

2. $2\ Cl^-_{(aq)} \rightarrow Cl_{2(g)} \quad + \quad 2\ e^-$

	m	55 kA
	70.90 g/mol	8.0 h
		9.65×10^4 C/mol

$$I = 55 \text{ kA} = 5.5 \times 10^4 \text{ C/s}$$
$$t = 8.0 \cancel{\text{h}} \times \frac{3600 \text{ s}}{1 \cancel{\text{h}}} = 2.9 \times 10^4 \text{ s}$$
$$n_{e^-} = \frac{q}{F}$$
$$= \frac{It}{F}$$
$$= \frac{5.5 \times 10^4 \frac{\cancel{\text{C}}}{\cancel{\text{s}}} \times 2.9 \times 10^4 \cancel{\text{s}}}{9.65 \times 10^4 \frac{\cancel{\text{C}}}{\text{mol}}}$$
$$n_{e^-} = 1.6 \times 10^4 \text{ mol}$$
$$n_{Cl_2} = 1.6 \times 10^4 \cancel{\text{mol}\ e^-} \times \frac{1 \text{ mol } Cl_2}{2 \cancel{\text{mol}\ e^-}}$$
$$n_{Cl_2} = 8.2 \times 10^3 \text{ mol}$$

$$m_{Cl_2} = 8.2 \times 10^3\ \cancel{\text{mol}} \times 70.90\ \frac{\text{g}}{\cancel{\text{mol}}}$$

$$m_{Cl_2} = 5.8 \times 10^5\ \text{g} = 0.58\ \text{Mg}$$

The mass of chlorine produced is 0.58 Mg or 0.58 t.

3. $Ag^+_{(aq)} + e^- \rightarrow Ag_{(s)}$

	e^-		$Ag_{(s)}$
	1.80 A		10.00 g
	9.65×10^4 C/mol		107.87 g/mol
	t		

$$I = 1.80\ \text{A} = 1.80\ \text{C/s}$$

$$n_{Ag} = 10.00\ \cancel{\text{g}} \times \frac{1\ \text{mol}}{107.87\ \cancel{\text{g}}}$$

$$n_{Ag} = 0.0927\ \text{mol}$$

$$n_{e^-} = 0.0927\ \cancel{\text{mol Ag}} \times \frac{1\ \text{mol e}^-}{1\ \cancel{\text{mol Ag}}}$$

$$= 0.0927\ \text{mol}$$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$t = \frac{n_{e^-}F}{I}$$

$$t = \frac{0.0927\ \cancel{\text{mol}} \times 9.65 \times 10^4\ \frac{\cancel{\text{C}}}{\cancel{\text{mol}}}}{1.80\ \frac{\cancel{\text{C}}}{\text{s}}}$$

$$t = 4.97 \times 10^3\ \cancel{\text{s}} \times \frac{1\ \text{min}}{60\ \cancel{\text{s}}}$$

$$t = 82.8\ \text{min}$$

The time to silverplate the teapot is 82.8 min.

4. $Al^{3+}_{(aq)} + 3\ e^- \rightarrow Al_{(l)}$

	$3\ e^-$		$Al_{(l)}$
	24.0 h		425 kg
	9.65×10^4 C/mol		26.98 g/mol
	I		

$$t = 24.0\ \cancel{\text{h}} \times \frac{3600\ \text{s}}{1\ \cancel{\text{h}}}$$

$$= 8.64 \times 10^4\ \text{s}$$

$$n_{Al} = 425\ \text{k}\cancel{\text{g}} \times \frac{1\ \text{mol}}{26.98\ \cancel{\text{g}}}$$

$$n_{Al} = 15.8\ \text{kmol}$$

$$n_{e^-} = 15.8\ \text{k}\cancel{\text{mol Al}} \times \frac{3\ \text{mol e}^-}{1\ \cancel{\text{mol Al}}}$$

$$n_{e^-} = 47.3\ \text{kmol}$$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$I = \frac{n_{e^-}F}{t}$$

$$I = \frac{47.3\ \text{k}\cancel{\text{mol}} \times 9.65 \times 10^4\ \frac{\text{C}}{\cancel{\text{mol}}}}{8.64 \times 10^4\ \text{s}}$$

$$I = 52.8\ \text{kC/s} = 52.8\ \text{kA}$$

The average current required is 52.8 kA.

5. (a) $Mg^{2+}_{(l)} + 2\ e^- \rightarrow Mg_{(s)}$

$Mg^{2+}_{(l)}$	+	$2\ e^-$	$\rightarrow$	$Mg_{(s)}$
		2.0×10^5 A		m
		18.0 h		24.31 g/mol
		9.65×10^4 C/mol		

$$I = 2.0 \times 10^5\ \text{A} = 2.0 \times 10^5\ \text{C/s}$$

$$t = 18.0\ \cancel{\text{h}} \times \frac{3600\ \text{s}}{1\ \cancel{\text{h}}} = 6.48 \times 10^4\ \text{s}$$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$= \frac{2.0 \times 10^5\ \frac{\cancel{\text{C}}}{\cancel{\text{s}}} \times 6.48 \times 10^4\ \cancel{\text{s}}}{9.65 \times 10^4\ \frac{\cancel{\text{C}}}{\text{mol}}}$$

$$n_{e^-} = 134\ \text{kmol}$$

$$n_{Mg} = 134\ \text{k}\cancel{\text{mol}\ e^-} \times \frac{1\ \text{mol Mg}}{2\ \cancel{\text{mol}\ e^-}}$$

$$n_{Mg} = 67.2\ \text{kmol}$$

$$m_{Mg} = 67.2\ \text{k}\cancel{\text{mol}} \times 24.31\ \frac{\text{g}}{\cancel{\text{mol}}}$$

$$m_{Mg} = 1.63 \times 10^3\ \text{kg} = 1.63\ \text{Mg}$$

The mass of magnesium produced is 1.63 Mg or 1.63 t.

(b)

$2\ Cl^-_{(aq)}$	$\rightarrow$	$Cl_{2(g)}$	+	$2\ e^-$
		m		134 kmol
		70.90 g/mol		

$$n_{Cl_2} = 134\ \text{k}\cancel{\text{mol}\ e^-} \times \frac{1\ \text{mol}\ Cl_2}{2\ \cancel{\text{mol}\ e^-}}$$

$$n_{Cl_2} = 67.2\ \text{kmol}$$

$$m_{Cl_2} = 67.2\ \text{k}\cancel{\text{mol}} \times 70.90\ \frac{\text{g}}{\cancel{\text{mol}}}$$

$$m_{Cl_2} = 4.76 \times 10^3\ \text{kg} = 4.76\ \text{Mg}$$

The mass of chlorine produced is 4.76 Mg or 4.76 t.

6.

$Co^{2+}_{(aq)}$	+	$2\ e^-$	$\rightarrow$	$Co_{(s)}$
250.0 mL		1.14 A		m
		2.05 h		58.93 g/mol
		9.65×10^4 C/mol		

$$I = 1.14\ \text{A} = 1.14\ \text{C/s}$$

$$t = 2.05\ \cancel{\text{h}} \times \frac{3600\ \text{s}}{1\ \cancel{\text{h}}} = 7.38 \times 10^3\ \text{s}$$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$= \frac{1.14\ \frac{\cancel{C}}{\cancel{s}} \times 7.38 \times 10^3\ \cancel{s}}{9.65 \times 10^4\ \frac{\cancel{C}}{\text{mol}}}$$

$$n_{e^-} = 0.0872\ \text{mol}$$

$$n_{Co^{2+}} = 0.0872\ \cancel{\text{mol e}^-} \times \frac{1\ \text{mol Co}^{2+}}{2\ \cancel{\text{mol e}^-}}$$

$$n_{Co^{2+}} = 0.0436\ \text{mol}$$

$$n_{CoSO_4} = 0.0436\ \cancel{\text{mol Co}^{2+}} \times \frac{1\ \text{mol CoSO}_4}{1\ \cancel{\text{mol Co}^{2+}}}$$

$$n_{CoSO_4} = 0.0436\ \text{mol}$$

$$C_{CoSO_4} = \frac{0.0436\ \text{mol}}{0.2500\ \text{L}}$$

$$C_{CoSO_4} = 0.174\ \text{mol/L}$$

The minimum molar concentration of cobalt(II) sulfate required is 0.174 mol/L.

7. $Cu_{(s)} \rightarrow Cu^{2+}_{(aq)} + 2\ e^-$

$m_i = 25.72$ g			0.876 A
m_f			75.0 min
63.55 g/mol			9.65×10^4 C/mol

$I = 0.876\ \text{A} = 0.876\ \text{C/s}$

$$t = 75.0\ \cancel{\text{min}} \times \frac{60\ \text{s}}{1\ \cancel{\text{min}}} = 4.50 \times 10^3\ \text{s}$$

$$n_{e^-} = \frac{q}{F}$$

$$n_{e^-} = \frac{It}{F}$$

$$= \frac{0.876\ \frac{\cancel{C}}{\cancel{s}} \times 4.50 \times 10^3\ \cancel{s}}{9.65 \times 10^4\ \frac{\cancel{C}}{\text{mol}}}$$

$$n_{e^-} = 0.0408\ \text{mol}$$

$$n_{Cu} = 0.0408\ \cancel{\text{mol e}^-} \times \frac{1\ \text{mol Cu}}{2\ \cancel{\text{mol e}^-}}$$

$$n_{Cu} = 0.0204\ \text{mol}$$

$$m_{Cu} = 0.0204\ \cancel{\text{mol}} \times 63.55\ \frac{\text{g}}{\cancel{\text{mol}}}$$

$$m_{Cu} = 1.30\ \text{g} \quad \text{(mass loss at the anode)}$$

The final mass of the copper anode will be (25.72 − 1.30) g = 24.42 g.

Making Connections

8. In a chlor-alkali cell, Faraday's law is critical to the process design because the quantities of electrical current required must be determined by the desired production of chemical products. The cost of power, size of conductors, and time of operation are all matters of concern to industrial processes. Process control just involves varying the quantity of charge through the cell, which will proportionally vary the amount of product.
9. (a) Chemical technicians prepare solutions; order inventory; maintain and clean equipment; set up bays/areas for experimentation; perform many kinds of analyses with all types of equipment; and maintain records of lab stocks, policies, and procedures.
   (b) Chemical technician education requirements vary, but usually include certification in a two- or three-year instruction program at a technical school or college.
   (c) (Educational facilities listed may be local facilities or those farther afield.)
   (d) (Job listings will, of course, vary with the newspaper selected and the date.)