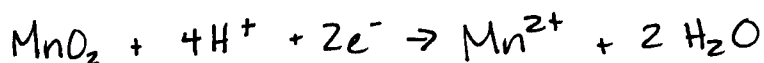
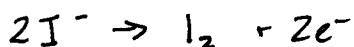


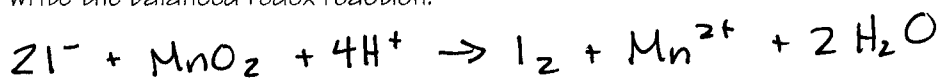
Electrochemistry Problems

1. When a solution containing iodide ion is mixed with manganese dioxide and acid, a cloud of purple iodine gas is given off. Use a table of half reactions to

a) write the half reactions that occur.

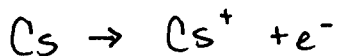


b) write the balanced redox reaction.

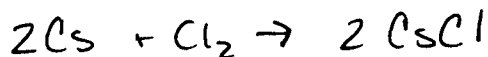
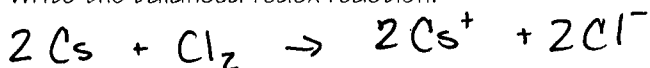


2. When hot cesium metal is exposed to chlorine gas, a bright flash occurs as the elements react. The product is a white solid composed of cesium ions and chloride ions.

a) Write the half reactions that occur.

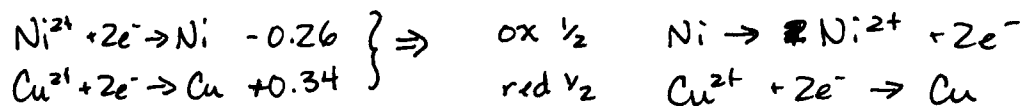


b) Write the balanced redox reaction.



3. A cell is made up as follows. A piece of nickel foil is immersed in a beaker of nickel(II) chloride solution, and a strip of copper foil is immersed in a beaker of copper(II) sulfate solution. A wire then connects the metal electrodes and the beakers connected by a salt bridge.

a) Write the half reactions that occur. Identify the oxidation half and the reduction half.



b) Which electrode is the anode?

Nickel

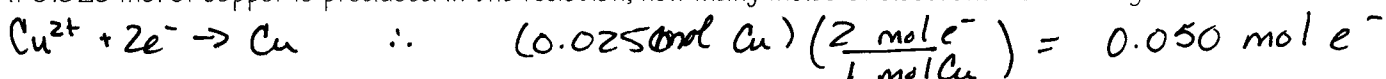
c) Toward which electrode do the sulfate ions migrate?

towards nickel (anode)

d) Which way do the electrons migrate in the wire?

from nickel (anode) to copper (cathode)

e) If 0.025 mol of copper is produced in the reaction, how many moles of electrons flow through the wire?

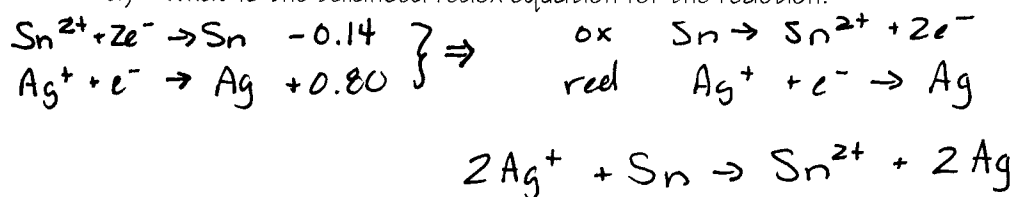


f) Toward which electrode do the nickel ions migrate?

towards Cu (cathode)

4. An electrochemical cell was made as follows. A weighed strip of tin was immersed in a beaker of one molar tin(II) sulfate and a weighed strip of silver was immersed in a second beaker containing one molar silver nitrate. A wire then connected the metal strips and a salt bridge connected the beakers.

a) What is the balanced redox equation for the reaction?



b) Which electrode is the cathode?

Ag

c) Towards which electrode do the silver ions migrate?

towards Ag (cathode)

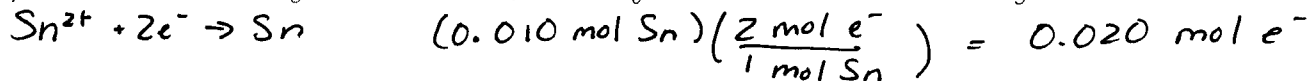
d) Which way do the electrons flow in the wire?

from Sn to Ag (anode to cathode)

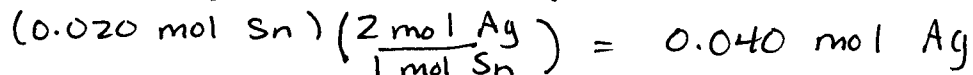
e) Did the silver electrode gain or lose mass?

gains mass ($\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$) silver ions change to silver + deposit on the cathode

f) If 0.010 mol of tin goes into solution, how many moles of electrons flow through the wire?



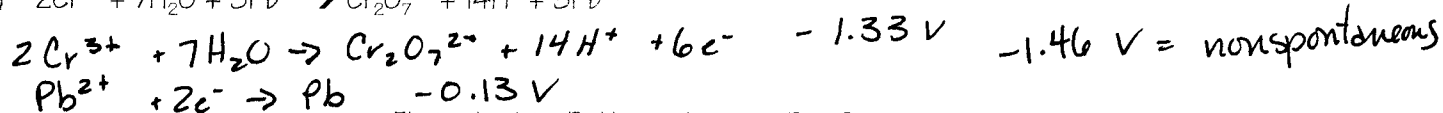
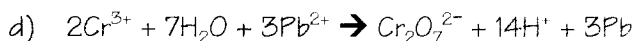
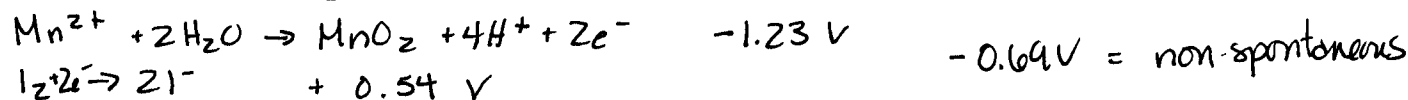
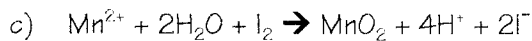
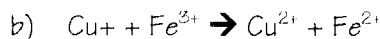
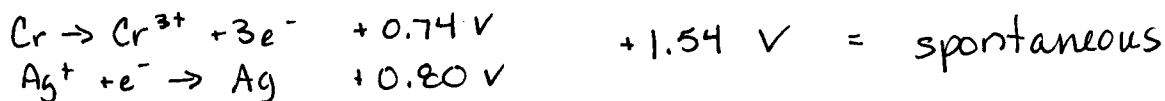
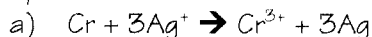
g) If 0.020 mol of tin goes into solution, how many moles of silver are involved in the reaction?



h) How many moles of electrons flow through the salt bridge in part (g)?

none - electrons flow through the wire not the salt bridge.

5. Calculate the potential for the following cells and indicate whether the reaction is expected to be spontaneous.



6. Which is the stronger oxidizing agent?

a) Zn^{2+} or Ca^{2+}

-0.76 -2.84

Zn^{2+}

b) Br_2 or I_2

1.06 0.54

Br_2

7. Which is the stronger reducing agent?

a) Mn or Pb

1.18 0.13

Mn

b) Ba or Sn

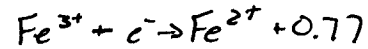
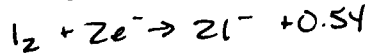
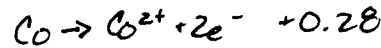
2.92 0.14

Ba

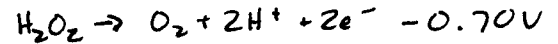
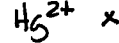
8. Which of Cr, I_2 , Al and Fe^{3+} will oxidize Co?

Cr, Al can't reduce, \therefore cannot oxidize Co

I_2 or Fe^{3+}

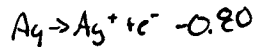
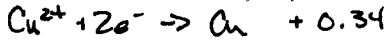


9. Which of H_2 , Cl_2 , Hg^{2+} , and H_2O_2 will reduce Ag^+ ?



H_2 or H_2O_2

10. Which of Cu^{2+} , Zn, acidic NO_3^- , and Cl^- will act as oxidizing agents for Ag?

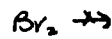
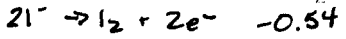


Zn \nrightarrow

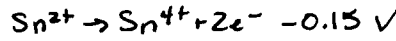
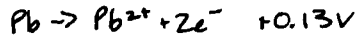
$Cl^- \nrightarrow$

only NO_3^-

11. Which of I^- , Pb, Br_2 , and Sn^{2+} will act as oxidizing agents for Sn^{4+} ?



reducing



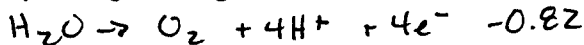
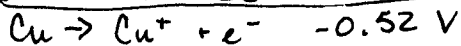
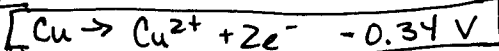
\therefore only Pb

12. Predict the reaction that will be favoured in the following cells.

a) A mixture of Br_2 and Cl_2 is added to a beaker containing copper(II) sulfate and a copper rod.

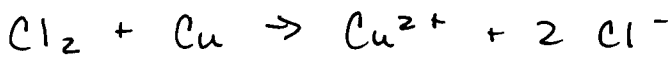
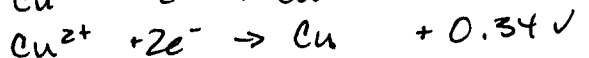
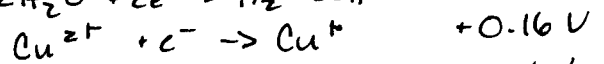
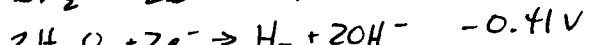
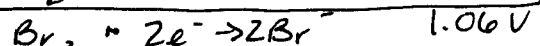
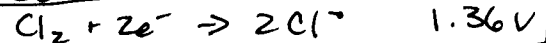
Br_2 , Cl_2 , Cu^{2+} , SO_4^{2-} , Cu, H_2O

ox



red

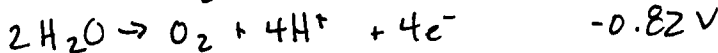
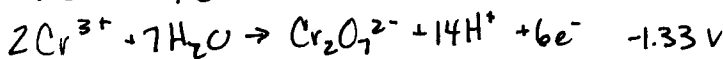
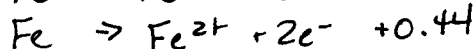
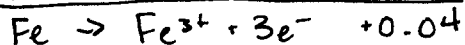
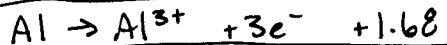
ox



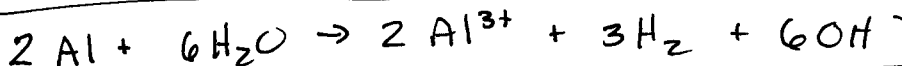
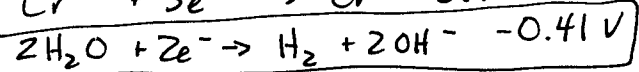
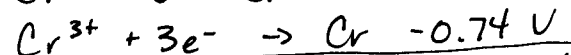
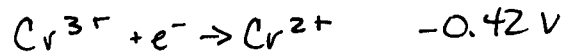
b) A mixture of powdered Al and Fe is added to a beaker of Cr^{3+} solution.

Al, Fe, Cr^{3+} , H_2O

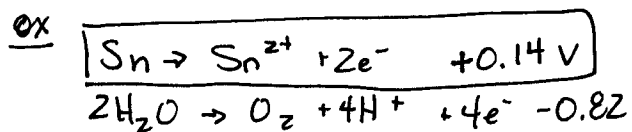
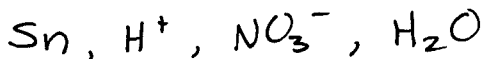
ox



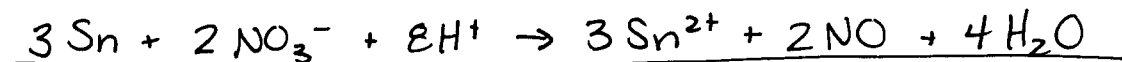
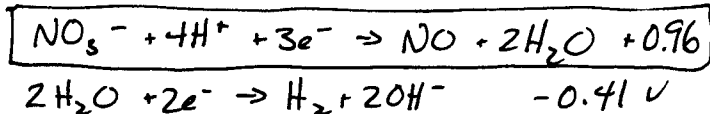
red



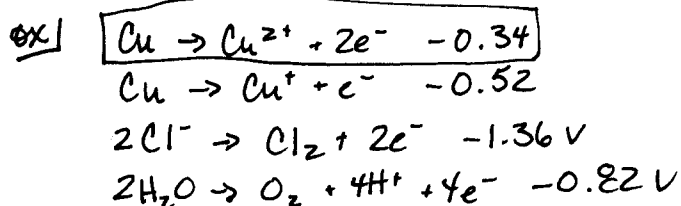
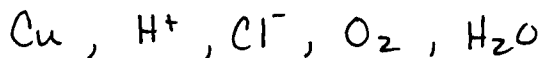
c) A tin strip is immersed in nitric acid.



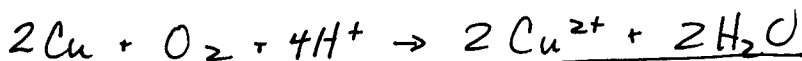
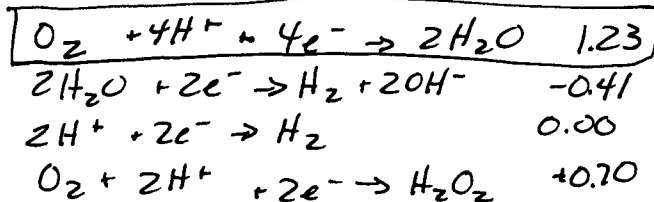
red



d) A copper rod is immersed in a 1 M solution of HCl, through which is bubbled O_2 at 101.3 kPa.

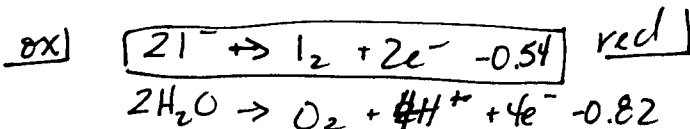


red

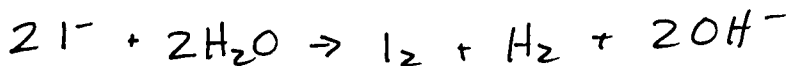
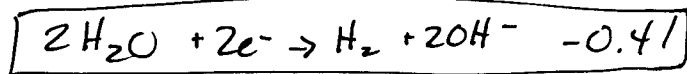


13. Predict the overall reactions that you would expect when the following are electrolyzed. Calculate the minimum voltage that must be applied to the cell.

a) 1 M NaI $\text{Na}^+, \text{I}^-, \text{H}_2\text{O}$

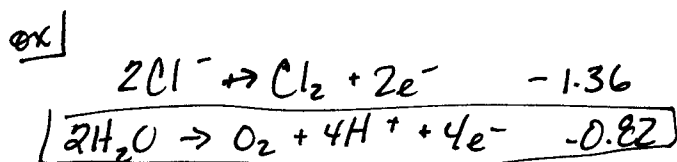


red

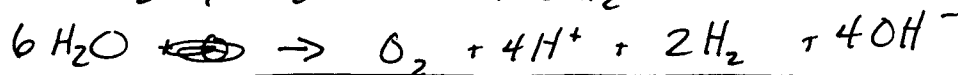
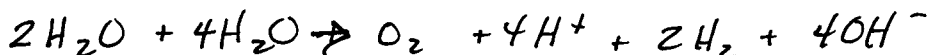
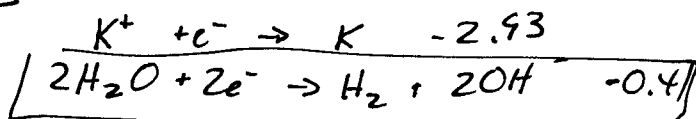


~~0.96~~ ^{0.95V} V must be applied

b) 1M KCl $\text{K}^+, \text{Cl}^-, \text{H}_2\text{O}$

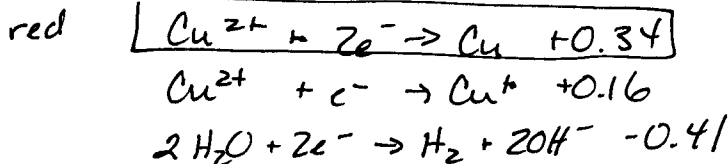
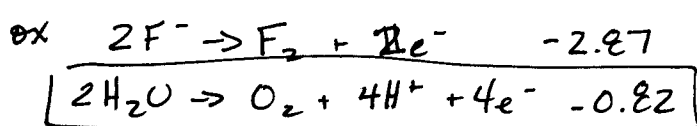


red



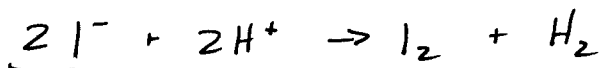
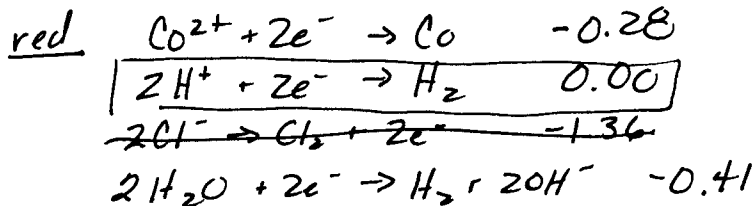
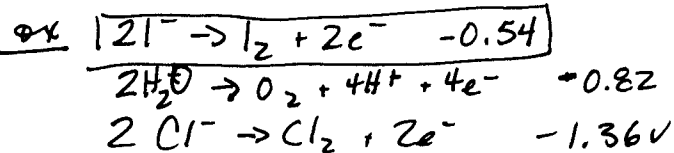
1.23V must be applied

c) 1 M CuF₂ Cu²⁺, F⁻, H₂O



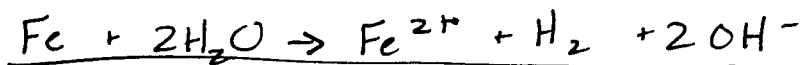
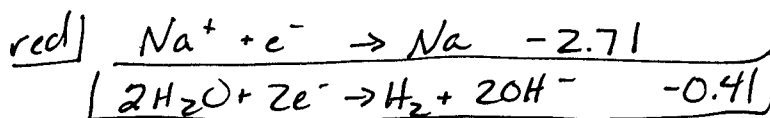
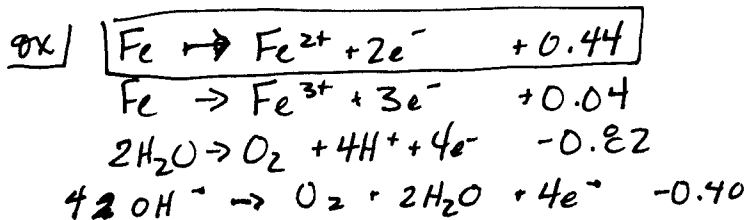
0.48 V must be applied

d) 1 M CoI₂ and 1 M HCl Co²⁺, I⁻, H⁺, Cl⁻, H₂O



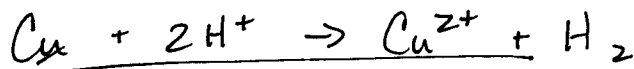
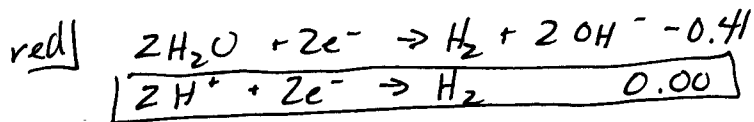
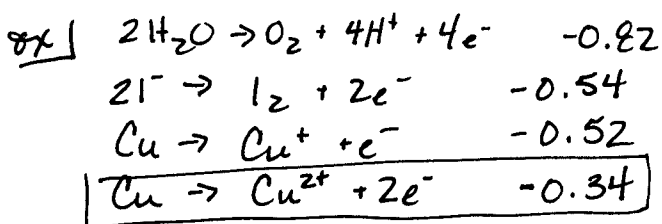
0.54 V must be applied

e) 1 M NaOH, using Fe electrodes Na⁺, OH⁻, Fe, H₂O



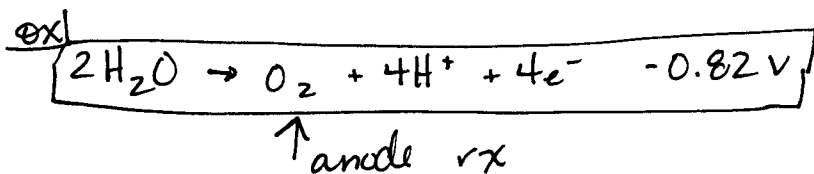
spontaneous
 +0.03V
 no voltage required

f) 1 M HI, using Cu electrodes H⁺, I⁻, Cu, H₂O

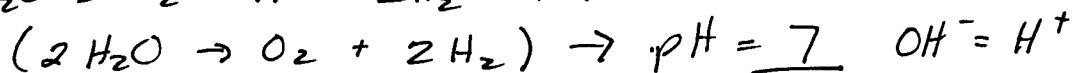
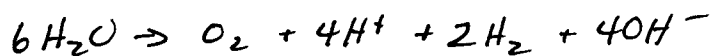
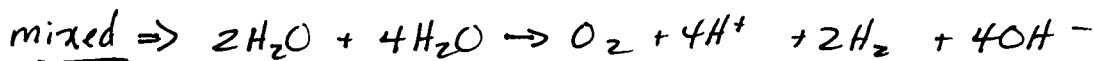


0.34 V must be applied

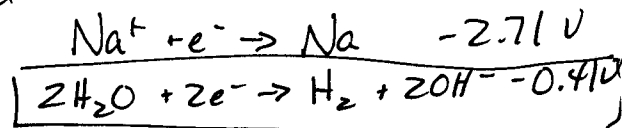
14. An aqueous solution of sodium sulfate is electrolyzed. If litmus paper is dipped in the solution around the anode during electrolysis, what colour will the litmus turn? What colour will the litmus turn when dipped in the solution around the cathode? If the electric current is turned off and the anode and cathode solutions are stirred together, what will be the pH of the resulting solution?



anode \rightarrow H^+ produced
litmus turns red



red



↑
cathode rx

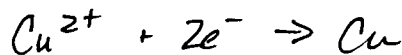
cathode \rightarrow ~~be~~ OH^- produced
litmus turns blue

15. How many moles of Cu can be produced by passing a 2.50 A current through 1 M CuSO_4 for 4000 s?

$$\text{coulombs} = (2.50 \text{ A})(4000. \text{ s}) = 10\,000 \text{ C}$$

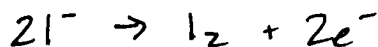
$$\frac{10\,000 \text{ C}}{96\,500 \text{ C/mol e}^-}$$

$$= 0.104 \text{ mol e}^-$$



$$(0.104 \text{ mol e}^-) \left(\frac{1 \text{ mol Cu}}{2 \text{ mol e}^-} \right) \left(\frac{\cancel{63.546 \text{ g}}}{\cancel{\text{mol}}} \right) = \frac{\cancel{3.29 \text{ g Cu}}}{0.052 \text{ mol Cu}}$$

16. How many coulombs are required to produce 0.325 g of I_2 by electrolysis of an aqueous solution of KI?



$$\left(\frac{0.325 \text{ g I}_2}{253.809 \text{ g/mol}} \right) \left(\frac{2 \text{ mol e}^-}{1 \text{ mol I}_2} \right) = 0.00256 \text{ mol e}^-$$

$$(0.00256 \text{ mol e}^-) (96\,500 \text{ C/mol e}^-) = \underline{247 \text{ C}}$$

17. A 12.5 A current was passed through a 1.00 M solution of lead(II) nitrate for 1.00 h using inert electrodes. How much will the mass of the cathode have increased after 1.00 h?

$$\text{coulombs} = (12.5 \text{ A})(3600 \text{ s}) = 45\,000 \text{ C}$$

$$\frac{45\,000 \text{ C}}{96\,500 \text{ C/mol } e^-} = 0.466 \text{ mol } e^- \quad \text{Pb}^{2+} + 2e^- \rightarrow \text{Pb}$$

$$(0.466 \text{ mol } e^-) \left(\frac{1 \text{ mol Pb}}{2 \text{ mol } e^-} \right) (207.2 \text{ g/mol}) = \underline{\underline{48.3 \text{ g}}}$$

18. What quantity of electricity (in coulombs) is required to produce 1.00 kg of Br₂ by electrolysis of KBr solution?



$$\left(\frac{1000 \text{ g Br}_2}{159.808 \text{ g/mol}} \right) \left(\frac{2 \text{ mol } e^-}{1 \text{ mol Br}_2} \right) (96\,500 \text{ C/mol } e^-) = \underline{\underline{1.21 \times 10^6 \text{ C}}}$$

19. What mass of tin can be plated out of a Sn²⁺ solution if we pass 3.00 A for 6.00 h?

$$\text{coulombs} = (3.00 \text{ A})(21\,600 \text{ s}) = 64\,800 \text{ C} \quad \text{Sn}^{2+} + 2e^- \rightarrow \text{Sn}$$

$$\left(\frac{64\,800 \text{ C}}{96\,500 \text{ C/mol } e^-} \right) \left(\frac{1 \text{ mol Sn}}{2 \text{ mol } e^-} \right) (118.69 \text{ g/mol}) = \underline{\underline{39.9 \text{ g Sn}}}$$

20. A certain amount of electricity deposits 45.0 g of silver from a solution containing silver ions. What mass of copper will this amount of electricity deposit from a solution of copper(II) sulfate?



$$\left(\frac{45.0 \text{ g Ag}}{107.868 \text{ g/mol}} \right) \left(\frac{1 \text{ mol } e^-}{1 \text{ mol Ag}} \right) = 0.417 \text{ mol } e^-$$

$$(0.417 \text{ mol } e^-) \left(\frac{1 \text{ mol Cu}}{2 \text{ mol } e^-} \right) (63.546 \text{ g/mol}) = \underline{\underline{13.3 \text{ g Cu}}}$$