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OpenCourseWare (2023)

## **CHEMISTRY II**

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## **SOLUTIONS OF ELECTROCHEMISTRY II EXERCISES**

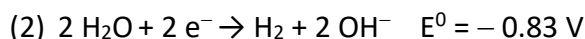


**Exercise 1.** Predict the products resulting from the electrolysis of 1 M NaBr (aq).

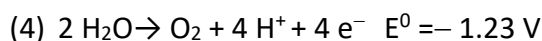
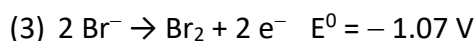
Data:  $E^0(\text{Na}^+/\text{Na}) = -2.71 \text{ V}$ ;  $E^0(\text{Br}_2/\text{Br}^-) = +1.07 \text{ V}$ ;  $E^0(\text{O}_2/\text{H}_2\text{O}, \text{H}^+) = +1.23 \text{ V}$ ;  $E^0(\text{H}_2\text{O}/\text{H}_2, \text{OH}^-) = -0.83 \text{ V}$ .

### SOLUTION

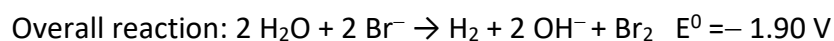
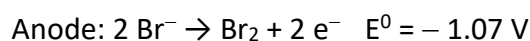
Cathode (2 possibilities):



Anode (2 possibilities):



Overall Reaction:

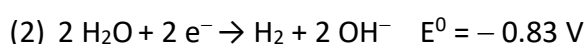


**Exercise 2.** An aqueous LiCl solution is electrolyzed and the products formed at the anode and cathode are chlorine gas and hydrogen gas, respectively. Describe the electrolysis in terms of the reactions at the electrodes.

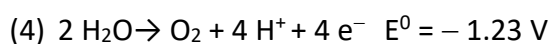
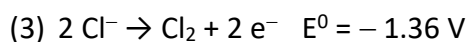
Data:  $E^0(\text{Li}^+/\text{Li}) = -3.05 \text{ V}$ ;  $E^0(\text{Cl}_2/\text{Cl}^-) = +1.36 \text{ V}$ ;  $E^0(\text{O}_2/\text{H}_2\text{O}, \text{H}^+) = +1.23 \text{ V}$ ;  $E^0(\text{H}_2\text{O}/\text{H}_2, \text{OH}^-) = -0.83 \text{ V}$ .

### SOLUTION

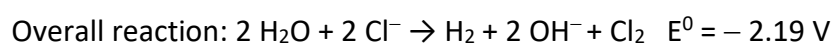
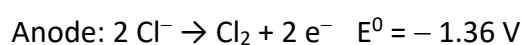
Cathode (2 possibilities):



Anode (2 possibilities):



Overall Reaction:



**Exercise 3.** A current of 1.62 A is passed through a  $\text{Cu}^{2+}$  solution for 1.00 h. What is the mass of metallic Cu that will be deposited on the cathode?

Data:  $M(\text{Cu}) = 63.5 \text{ g/mol}$ .

### SOLUTION

Reduction (Cathode):  $\text{Cu}^{2+} + 2 \text{e}^- \rightarrow \text{Cu}$

$$m(\text{Cu}) = M(\text{Cu}) \times I \times t / (n^\circ \text{e}^- \times F)$$

$$m(\text{Cu}) = 63.5 \text{ g mol}^{-1} \times 1.62 \text{ A} \times 3600 \text{ s} / (2 \times 96500 \text{ C mol}^{-1}) = 1.92 \text{ g}.$$

**Exercise 4.** Determine the time, in hours, required to electroplate 7.00 g of magnesium metal from molten magnesium chloride using a current of 7.30 A. What volume of chlorine gas at 25 °C and 1 atm will be produced at the anode?

Data: Atomic mass:  $\text{Mg} = 24.3$ ;  $F = 96500 \text{ C/mol e}^-$ .

### SOLUTION

Reduction (Cathode):  $\text{Mg}^{2+} + 2 \text{e}^- \rightarrow \text{Mg}$

Faraday Law:  $t = m(\text{Mg}) \times n^\circ \text{e}^- \times F / (M(\text{Mg}) \times I)$

$$t = 7 \text{ g} \times 2 \times 96500 \text{ C mol}^{-1} / (24.3 \text{ g mol}^{-1} \times 7.3 \text{ A}) = 7615.99 \text{ s} = 2.11 \text{ h}$$

Oxidation (Anode):  $2 \text{Cl}^- \rightarrow \text{Cl}_2 + 2 \text{e}^-$

$$n(\text{Cl}_2) = I \times t / (n^\circ \text{e}^- \times F)$$

$$n(\text{Cl}_2) = 7.3 \text{ A} \times 7615.99 \text{ s} / (2 \times 96500 \text{ C mol}^{-1}) = 0.288 \text{ mol}$$

$$V(\text{Cl}_2) = n(\text{Cl}_2) \times R \times T / P = 0.288 \text{ mol} \times 0.082 \text{ atm L K}^{-1} \text{ mol}^{-1} \times 298 \text{ K} / 1 \text{ atm} = 7.04 \text{ L}.$$

**Exercise 5.** One of the half-reactions for the electrolysis of water is:  $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$ . If 0.8445 L of  $\text{H}_2$  is collected at 25 °C and 782 mmHg, how many coulombs had to pass through the solution? How many moles of electrons will be involved in this process?

Data:  $F = 96500 \text{ C mol}^{-1}$ ,  $R = 0.082 \text{ atm L mol}^{-1} \text{ K}^{-1} = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ .

### SOLUTION

Reduction (Cathode):  $2 \text{H}^+ + 2 \text{e}^- \rightarrow \text{H}_2$

$$n(\text{H}_2) = P \times V(\text{Cl}_2) / R \times T = (780/760) \text{ atm} \times 0.8445 \text{ L} / 0.082 \text{ atm L K}^{-1} \text{ mol}^{-1} \times 298 \text{ K} = 0.0356 \text{ mol}$$

Faraday Law:

$$Q = n(\text{H}_2) \times n^\circ \text{e}^- \times F = 0.0356 \text{ mol} \times 2 \times 96500 \text{ C mol}^{-1} = 6870.8 \text{ C}$$

$$n(\text{e}^-) = Q / F = 6870.8 \text{ C} / 96500 \text{ C mol}^{-1} = 0.0712 \text{ mol of electrons are involved in the process.}$$