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OpenCourseWare (2023)

CHEMISTRY II

Verónica San Miguel Arnanz

Teresa Pérez Prior

Berna Serrano Prieto

Department of Materials Science and Engineering and Chemical Engineering

SOLUTIONS OF ELECTROCHEMISTRY II EXERCISES

Exercise 1. Predict the products resulting from the electrolysis of 1 M NaBr (aq).
Data: $E^0(Na^+/Na) = -2.71$ V; $E^0(Br_2/Br^-) = +1.07$ V; $E^0(O_2/H_2O, H^+) = +1.23$ V; $E^0(H_2O/H_2, OH^-) = -0.83$ V.

SOLUTION

Cathode (2 possibilities):

(1) $Na^+ + 1\ e^- \rightarrow Na \quad E^0 = -2.71$ V

(2) $2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^- \quad E^0 = -0.83$ V

Anode (2 possibilities):

(3) $2\ Br^- \rightarrow Br_2 + 2\ e^- \quad E^0 = -1.07$ V

(4) $2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ e^- \quad E^0 = -1.23$ V

Overall Reaction:

Cathode: $2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^- \quad E^0 = -0.83$ V

Anode: $2\ Br^- \rightarrow Br_2 + 2\ e^- \quad E^0 = -1.07$ V

Overall reaction: $2\ H_2O + 2\ Br^- \rightarrow H_2 + 2\ OH^- + Br_2 \quad E^0 = -1.90$ V

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: $E^0(Li^+/Li) = -3.05$ V; $E^0(Cl_2/Cl^-) = +1.36$ V; $E^0(O_2/H_2O, H^+) = +1.23$ V; $E^0(H_2O/H_2, OH^-) = -0.83$ V.

SOLUTION

Cathode (2 possibilities):

(1) $Li^+ + 1\ e^- \rightarrow Li \quad E^0 = -3.05$ V

(2) $2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^- \quad E^0 = -0.83$ V

Anode (2 possibilities):

(3) $2\ Cl^- \rightarrow Cl_2 + 2\ e^- \quad E^0 = -1.36$ V

(4) $2\ H_2O \rightarrow O_2 + 4\ H^+ + 4\ e^- \quad E^0 = -1.23$ V

Overall Reaction:

Cathode: $2\ H_2O + 2\ e^- \rightarrow H_2 + 2\ OH^- \quad E^0 = -0.83$ V

Anode: $2\ Cl^- \rightarrow Cl_2 + 2\ e^- \quad E^0 = -1.36$ V

Overall reaction: $2\ H_2O + 2\ Cl^- \rightarrow H_2 + 2\ OH^- + Cl_2 \quad E^0 = -2.19$ V

Exercise 3. A current of 1.62 A is passed through a Cu^{2+} solution for 1.00 h. What is the mass of metallic Cu that will be deposited on the cathode?
Data: M(Cu) = 63.5 g/mol.

SOLUTION

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

m (Cu) = M (Cu) × I × t / (nº e^- × F)

m (Cu) = 63.5 g mol^{-1} × 1.62 A × 3600 s / (2 × 96500 C mol^{-1}) = 1.92 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: Mg = 24.3; F = 96500 C/mol e^-.

SOLUTION

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

Faraday Law: t = m (Mg) × nº e^- × F /(M (Mg) × I)

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

Oxidation (Anode): $2\ Cl^- \rightarrow Cl_2 + 2\ e^-$

n (Cl_2) = I × t / (nº e^- × F)

n (Cl_2) = 7.3 A × 7615.99 s / (2 × 96500 C mol^{-1}) = 0.288 mol

V (Cl_2) = n (Cl_2) × R × T / P = 0.288 mol × 0.082 atm L K^{-1} mol^{-1} × 298 K/1 atm = 7.04 L.

Exercise 5. One of the half-reactions for the electrolysis of water is: $2H^+$ (aq) $+2e^- \rightarrow H_2$ (g). If 0.8445 L of H_2 is collected at 25 ºC 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 C mol^{-1}, R = 0.082 atm L mol^{-1} K^{-1} = 8.314 J K^{-1} mol^{-1}.

SOLUTION

Reduction (Cathode): $2\ H^+ + 2\ e^- \rightarrow H_2$

n (H_2) = P × V (Cl_2)/R × T = (780/760) atm × 0.8445 L / 0.082 atm L K^{-1} mol^{-1} × 298 K = 0.0356 mol

Faraday Law:

Q = n (H_2) × nº e^- × F = 0.0356 mol × 2 × 96500 C mol^{-1} = 6870.8 C

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