B11 · Faraday's law with the unknown chosen

Student notes - follow the slides, fill the blanks, work the questions

Goals: Choose the starting point of the Faraday chain from the givens and the question. Find a current, a time, an ion charge or a mass in an electrolysis. Use Faraday’s law in a voltaic cell and use the mass gained at a cathode.

Name: _____ Date: _____

Slide 1 of 8 · One chain, any unknown

Every Faraday problem uses the same chain: current and time, charge, moles of _____, moles of metal, and _____.

Step one: write the _____ and the question. Step two: start at a given quantity and walk toward the _____.

Starting with current and time means going forward: multiply for charge, _____ by F, then divide by the electron coefficient.

Starting with a mass means going backward: _____ by the electron coefficient, then multiply by _____ to get charge.

Example. A problem gives the mass of silver deposited and the time, and asks for the current. Which quantity do you start with, which direction do you walk, and what do you do at each step?

Work:

Answer: _____

Try it. A problem gives the current and the time and asks for the mass of copper deposited. Which direction do you walk, and what do you do at each step?

Work:

Answer: _____

Slide 2 of 8 · Finding the current

The question gives a mass and a time and asks for the current. Start with the mass and go _____: n(Cu) = m ÷ M.

In $Cu^{2+} + 2e^- \rightarrow Cu$, multiply the moles of copper by _____ to get moles of electrons. Then multiply by _____ to get the charge.

Current is charge divided by time: I = _____. The time must be in _____.

Leaving the time in minutes makes the current _____ too big.

Example. A copper cathode gains 1.25 g in 40.0 minutes from Cu^{2+} solution. What constant current was used? M(Cu) = 63.55 g/mol.

Work:

Answer: _____

Try it. A zinc cathode gains 0.450 g in 30.0 minutes from Zn^{2+} solution. What constant current was used? M(Zn) = 65.41 g/mol.

Work:

Answer: _____

Slide 3 of 8 · Finding the ion charge

When the half-reaction is unknown, let _____ be the number of electrons each ion gains. It is also the _____ on the ion.

Find the charge first: q = It. Then the moles of electrons are n(e^-) = _____.

Find the moles of metal from its mass: n(metal) = _____.

Then z = n(e^-) ÷ n(metal). Round z to the nearest _____. If z = 2.00, the ion has a charge of _____.

Example. A metal with a molar mass of 63.55 g/mol is plated from a solution of its ions by 2.00 A for 20.0 minutes. The mass deposited is 0.790 g. What is the charge on the ion?

Work:

Answer: _____

Try it. A metal with a molar mass of 58.69 g/mol is plated from a solution of its ions by 1.00 A for 40.0 minutes. The mass deposited is 0.730 g. What is the charge on the ion?

Work:

Answer: _____

Slide 4 of 8 · The chain in a voltaic cell

In a voltaic cell the electrons in the wire come from the _____ half-reaction and are used in the _____ half-reaction.

The charge that flows is q = It, so n(e^-) = _____. These same electrons pass through both electrodes.

At the anode, Zn → Zn^{2+} + _____, so n(Zn) = n(e^-) ÷ 2. The zinc anode _____ mass.

At the cathode, Cu^{2+} + $2e^-$ → Cu, so the copper cathode _____ mass. The moles are equal, but the masses differ because the _____ differ.

Example. A zinc and copper voltaic cell gives a steady 0.500 A for 30.0 minutes. What mass of zinc dissolves from the anode, and what mass of copper deposits on the cathode? M(Zn) = 65.41 g/mol and M(Cu) = 63.55 g/mol.

Work:

Answer: _____

Try it. A zinc and copper voltaic cell gives a steady 0.250 A for 2.00 hours. What mass of zinc dissolves from the anode, and what mass of copper deposits on the cathode? M(Zn) = 65.41 g/mol and M(Cu) = 63.55 g/mol.

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 5 of 8 · Your turn: gases from an aqueous solution

The same current supplies electrons at _____ electrodes, so one value of $n(e^-)$ feeds both half-reactions.

Cathode: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$. One H_2 needs _____ electrons, so $n(H_2) = n(e^-) \div 2$.

Anode: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$. One O_2 releases _____ electrons, so $n(O_2) = n(e^-) \div$ _____.

Check: $n(H_2)$ is _____ $n(O_2)$, which matches $2H_2O \rightarrow 2H_2 + O_2$. Read whether the question asks for _____ or grams.

Example. $Na_2SO_4(aq)$ is electrolyzed with inert electrodes using 2.00 A for 30.0 minutes. The half-reactions are $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ and $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$. Find the moles of hydrogen and oxygen formed.

Work:

Answer: _____

Try it. $Na_2SO_4(aq)$ is electrolyzed with inert electrodes using 1.60 A for 30.0 minutes. Find the moles of hydrogen and oxygen formed.

Work:

Answer: _____

Slide 6 of 8 · Mass gained, then time

When an electrode is weighed twice, subtract: mass gained = _____. Do not use the _____ alone.

Then n(Cu) = m ÷ M with M = _____. Because $Cu^{2+} + 2e^- \rightarrow Cu$, n($e^-$) = _____ × n(Cu).

The charge is q = n(e^-) × _____. The time is t = q ÷ _____, where I is the current in amperes.

Give the time in the unit the question asks for. Divide seconds by _____ to get minutes.

Example. A cathode has a mass of 14.200 g before copper plating and 14.850 g after. The current was 1.50 A. How long did the plating run, in minutes? M(Cu) = 63.55 g/mol.

Work:

Answer: _____

Try it. A cathode has a mass of 25.300 g before silver plating and 26.085 g after. The current was 0.900 A. How long did the plating run, in minutes? The half-reaction is $Ag^+ + e^- \rightarrow Ag$. M(Ag) = 107.87 g/mol.

Work:

Answer: _____

Slide 7 of 8 · Method: how to solve a Faraday problem when the unknown changes

Step 1. Write the _____: I and t, then q, then n(e^-), then n(substance), then m.

Step 2. Mark the _____ piece and the unknown piece.

Step 3. Move from the given toward the unknown. _____ each step when you go backward.

Step 4. _____. Carry an extra digit in the middle lines.

Step 5. Run the chain _____ with your answer and compare to the given.

Example. Use the method on a cathode that has a mass of 14.200 g before copper plating and 14.850 g after. The current was 1.50 A. Find the time.

Work:

Answer: _____

Try it. Use the method on a cathode that gains 0.850 g of silver in 15.0 minutes from $Ag^+ + e^- \rightarrow Ag$. M(Ag) = 107.87 g/mol. Find the current.

Work:

Answer: _____

Slide 8 of 8 · Mass at the anode

In copper refining, the impure copper is the _____. It dissolves: $Cu \rightarrow Cu^{2+} +$ _____.

The same electrons leave the anode and arrive at the _____, so the Faraday chain works at both electrodes.

Change hours to seconds first: 2.00 h = _____ s. Then $q = It$ and $n(e^-) = q \div F$.

Each copper atom gives _____ electrons, so $n(Cu) = n(e^-) \div 2$. The anode _____ this mass.

Example. In copper refining, a copper anode dissolves and pure copper plates onto the cathode. A current of 10.0 A runs for 2.00 hours. What mass of copper dissolves from the anode? M(Cu) = 63.55 g/mol.

Work:

Answer: _____

Try it. In copper refining, a current of 6.00 A runs for 1.00 hour. What mass of copper dissolves from the anode? M(Cu) = 63.55 g/mol.

Work:

Answer: _____

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Faraday's law with the unknown chosen | Questions 1-2 of 7

1. Given a cathode that gains 0.850 g of silver in 15.0 minutes from $Ag^+ + e^- \rightarrow Ag$ (M = 107.87 g/mol). Find the constant current.

Work:

Final answer (with unit): _____

2. Given 1.50 A for 30.0 minutes and 0.485 g of a metal deposited (M = 52.00 g/mol). Find the charge on the metal ion.

Work:

Final answer (with unit): _____

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Faraday's law with the unknown chosen | Questions 3-4 of 7

3. Given a zinc and copper voltaic cell that delivers 0.800 A for 45.0 minutes (M(Zn) = 65.41; M(Cu) = 63.55 g/mol). Find the mass of zinc lost and the mass of copper gained.

Work:

Final answer (with unit): _____

4. Given $Na_2SO_4(aq)$ with inert electrodes and 3.00 A for 20.0 minutes. Find the moles of hydrogen and oxygen formed.

Work:

Final answer (with unit): _____

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Faraday's law with the unknown chosen | Questions 5-6 of 7

5. Given a cathode of 20.00 g that has a mass of 21.20 g after copper plating at 2.00 A. Find the time in minutes (M(Cu) = 63.55 g/mol).

Work:

Final answer (with unit): _____

6. Given a copper anode in a refining cell with 5.00 A for 90.0 minutes. Find the mass lost by the anode (M(Cu) = 63.55 g/mol).

Work:

Final answer (with unit): _____

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7. Challenge: Given 2.00 A for 25.0 minutes, which deposits 0.912 g of an unknown metal from a solution of its 2+ ions. Find the molar mass of the metal in g/mol. Then name the metal, using the periodic table in the Data Booklet. Use F = 9.65×10^4 C/mol e^-.

Work:

Final answer (with unit): _____