B11 · Faraday's law with the unknown chosen

Student notes - complete the underlined spaces | Notes 1/3

Start the Faraday chain from the given quantities to find a current, a time, an ion charge or a mass, and use the same charge in cells in series.

Name: _____ Date: _____

1. One chain, any unknown

Choose the direction

In B10 we built one chain: current and time give _____, charge gives moles of electrons, the half-reaction gives moles of _____, and the molar mass gives the _____.

Every Faraday problem uses this same chain. Only the given end and the asked end change.

So write the _____ and the question first. Then start at a given and walk toward the _____.

If the mass is given, go _____. Multiply by the coefficient of the electrons and then by _____. Going forward, you divide, because each step reverses.

On the diploma: many wrong options divide when they should multiply, or the other way round.

Watch: Two kinds of question (Alberta Chemistry Teacher, “Chemistry 30 - Cell stoichiometry theory and examples”, 2:04)

Watch: Working backward from the mass (Alberta Chemistry Teacher, “Chemistry 30 - Cell stoichiometry theory and examples”, 20:02)

Find a current

A copper cathode gains 1.25 g in 40.0 min from Cu^{2+}. The mass is given, so start there: n(Cu) = 1.25 ÷ 63.55 = _____ mol.

$Cu^{2+} + 2e^- \rightarrow Cu$, so multiply by 2: $n(e^-)$ = _____ mol. Moles to coulombs means multiply by F.

q = 0.03934 × (9.65 × 10^4) = _____ C. The time is 40.0 × 60 = 2400 s, so I = q ÷ t = 3796 ÷ 2400 = _____.

Leaving the time in minutes would make the current 60 times too big. On the diploma: write givens with units, like t = 40.0 min, so you see what to convert.

Zn/Cu cell, 0.500 A for 30.0 min. q = _____

$n(e^-) = 900 \div (9.65 \times 10^4)$ = _____

$Zn \rightarrow Zn^{2+} + 2e^-$, so zinc lost = _____

$Cu^{2+} + 2e^- \rightarrow Cu$, so copper gained = _____

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Student notes - complete the underlined spaces | Notes 2/3

2. Ion charge and the voltaic cell

Find the ion charge

Sometimes the ion is the mystery. Let z be the number of electrons each ion gains. Given 2.00 A for 20.0 min and 0.790 g of a metal with M = 63.55 g/mol.

The time is 1200 s, so q = _____ C and n(e^-) = 2400 ÷ (9.65×10^4) = _____ mol.

n(metal) = 0.790 ÷ 63.55 = _____ mol. Dividing electrons by atoms gives electrons per atom: z = _____, so the ion is M^{2+}.

z must be a _____ number, because ion charges are whole numbers. Round to the nearest integer. On the diploma: do not report 2.0007.

The chain in a voltaic cell

An electrode is a piece of metal where a half-reaction happens. In a voltaic cell, the electrons in the wire come from the _____ and go to the _____.

So the same chain links the charge to the mass at both electrodes. A Zn/Cu cell gives 0.500 A for 30.0 min: q = 0.500 × 1800 = _____ C.

Then n(e^-) = 900 ÷ (9.65×10^4) = _____ mol. Both half-reactions use 2 electrons per atom, so n(Zn) = n(Cu) = _____ mol.

The zinc anode loses 0.004663 × 65.41 = _____ g. The copper cathode gains 0.004663 × 63.55 = _____ g. The moles are equal, but the molar _____ are different.

On the diploma: say which electrode loses mass and which gains mass.

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Student notes - complete the underlined spaces | Notes 3/3

3. Gases, mass gained and the anode

Gases from water

$Na_2SO_4(aq)$ is electrolyzed with inert electrodes, which carry electrons but do not react. At 2.00 A for 30.0 min, q = _____ C and $n(e^-)$ = _____ mol.

Reduction: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$. It makes one H_2 for two electrons, so $n(H_2)$ = 0.0373 ÷ 2 = _____ mol.

Oxidation: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$. It makes one O_2 for four electrons, so $n(O_2)$ = 0.0373 ÷ 4 = _____ mol.

The same electrons pass through the whole circuit. Hydrogen forms in a ratio of _____ to _____ with oxygen, as in $2H_2O \rightarrow 2H_2 + O_2$.

On the diploma: a wrong option divides by 2 for oxygen. Use the 4 from the oxidation half-reaction.

Mass gained and mass lost

Use the mass _____ by the cathode. A cathode that goes from 14.20 g to 14.85 g gained _____ g.

With 1.50 A, n(Cu) = 0.65 ÷ 63.55 = 0.01023 mol and $n(e^-)$ = 0.02046 mol. Then q = 1974 C and t = 1974 ÷ 1.50 = _____ s, or 21.9 min.

In copper refining, the anode loses mass: $Cu \rightarrow Cu^{2+} + 2e^-$. For 10.0 A for 2.00 h, the time is 7200 s and q = _____ C.

Then $n(e^-)$ = 0.746 mol and n(Cu) = 0.373 mol, so the anode loses _____ g of copper. If no electrons go to side reactions, the pure cathode gains the same amount.

B11 · Practice

Faraday's law with the unknown chosen | Questions 1-3 of 12

State symbols: (s) solid, (aq) dissolved in water, (l) liquid, (g) gas. Use the supplied reaction and conditions. B4 values name the Alberta Chemistry 30 Data Booklet table where used.

B11-P01 · Easy · A cathode gains 0.850 g of silver in 15.0 minutes from $Ag^+ + e^- \rightarrow Ag$ (M = 107.87 g/mol). Find the constant current.

B11-P02 · Easy · A cathode gains 2.50 g of nickel in 30.0 minutes from $Ni^{2+} + 2e^- \rightarrow Ni$ (M = 58.69 g/mol). Find the current.

B11-P03 · Easy · A student finds the current by dividing the charge by the time in minutes. Explain the error and the fix.

B11 · Practice

Faraday's law with the unknown chosen | Questions 4-6 of 12

B11-P04 · Easy · 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.

B11-P05 · Medium · A calculation of z gives 2.96. Explain why we state z = 3 and what the small difference tells us.

B11-P06 · Medium · A zinc and copper voltaic cell gives 0.800 A for 45.0 minutes. Find the mass of zinc lost from the anode (M = 65.41 g/mol).

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B11-P07 · Medium · For the same cell, find the mass of copper gained at the cathode (M = 63.55 g/mol), and explain why the two masses are different.

B11-P08 · Medium · $Na_2SO_4(aq)$ is electrolyzed with inert electrodes at 3.00 A for 20.0 minutes. Find the moles of hydrogen and oxygen formed.

B11-P09 · Challenging · For the same electrolysis, find the mass of hydrogen formed (M = 2.02 g/mol) and state the ratio of hydrogen to oxygen by moles.

B11 · Practice

Faraday's law with the unknown chosen | Questions 10-12 of 12

B11-P10 · Challenging · A cathode of 20.00 g has a mass of 21.20 g after copper plating at 2.00 A. Find the time in minutes (M = 63.55 g/mol).

B11-P11 · Challenging · A copper anode in a refining cell runs at 5.00 A for 90.0 minutes. Find the mass lost by the anode (M = 63.55 g/mol).

B11-P12 · Challenging · A student uses the final mass of a cathode, 21.20 g, to find a plating time. Explain the error and say whether the time is too large or too small.