B16 · Unit B review: choose the method

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

Goals: Choose the method a Unit B question needs. Use the table, Faraday’s law and a titration in turn. Explain corrosion protection, plating and bleaching with redox ideas.

Name: _____ Date: _____

Slide 1 of 8 · Sort the problem before you solve it

Choose the method before you touch a calculator. If the question asks about voltage, spontaneity or the anode, use the _____. If it gives current and time, or asks for a mass at an electrode, use _____.

If it asks for a concentration from the volume of a reactant, use a _____. What is given and the _____ point you to the method.

A positive E°reaction means the reaction runs by itself, so it can be a _____ cell. A negative E°reaction needs a power supply, so it is run as an _____ cell.

In both cell types, _____ happens at the anode and _____ happens at the cathode. Electrode names follow the reaction, not the cell type.

Example. Each Unit B problem asks about a cell, a charge or a titration. Choose the method for each. (a) Find the voltage of a zinc and silver cell. (b) Find the mass of silver from 3.00 A for 25.0 min. (c) Find $[Fe^{2+}]$ from the volume of MnO_4^- solution needed.

Work:

Answer: _____

Try it. Choose the method for each. (a) Find the mass of copper from 2.00 A for 10.0 min. (b) Find $[Fe^{2+}]$ from a permanganate titration. Then, for E°reaction = −0.50 V, name the cell type and the cathode reaction.

Work:

Answer: _____

Slide 2 of 8 · Combine half-reactions

Aluminium has the _____ E° (−1.66 V), so it is the anode and is oxidized: Al → Al^{3+} + _____. Silver is the cathode: $Ag^{+} + e^{-} \rightarrow Ag$.

Each silver ion takes only 1 electron, so _____ the silver half. Add the halves: Al + $3Ag^{+}$ → _____.

Check the balance. Al 1, Ag 3 and charge _____ on each side. A balanced equation must match in atoms and in _____.

E°reaction = E°cathode − E°anode = 0.80 − (−1.66) = _____. Do not _____ the silver value by three. A positive value means the reaction is spontaneous.

Example. Find the cell reaction and voltage for aluminium and silver half-cells at 1.0 mol/L. Given $E°(Al^{3+}/Al) = -1.66$ V and $E°(Ag^{+}/Ag) = +0.80$ V.

Work:

Answer: _____

Try it. Find the cell reaction and voltage for aluminium and copper half-cells at 1.0 mol/L. Given $E°(Al^{3+}/Al) = -1.66$ V and $E°(Cu^{2+}/Cu) = +0.34$ V.

Work:

Answer: _____

Slide 3 of 8 · From current and time to a mass

Current is charge per second. Change minutes to _____ first. The charge is q = _____, where I is the current in amperes and t is the time in seconds.

Divide the charge by Faraday's constant, _____ C/mol e^-, to get the moles of electrons. Here 4500 ÷ (9.65 × 10^4) = _____ mol.

The mole ratio comes from the half-reaction. $Ag^+ + e^- \rightarrow Ag$ needs 1 mol of electrons per mole of metal, $Cu^{2+} + 2e^- \rightarrow Cu$ needs _____, and $Al^{3+} + 3e^- \rightarrow Al$ needs _____.

Mass = moles × molar mass. For silver, 0.04663 mol × 107.87 g/mol = _____. A wrong mole ratio makes the mass wrong by that same factor.

Example. A current of 3.00 A runs for 25.0 min in a cell with a silver cathode in Ag^+ solution. Find the mass of silver deposited. Use F = 9.65 × 10^4 C/mol e^- and M(Ag) = 107.87 g/mol.

Work:

Answer: _____

Try it. A current of 2.50 A runs for 18.0 min in a cell with a copper cathode in Cu^{2+} solution. Find the mass of copper deposited. Use F = 9.65 × 10^4 C/mol e^- and M(Cu) = 63.55 g/mol.

Work:

Answer: _____

Slide 4 of 8 · Redox titration

A redox titration finds a concentration by reacting a sample with a solution of _____ concentration. Permanganate is reduced: $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} +$ _____.

Iron(II) is oxidized: $Fe^{2+} \rightarrow Fe^{3+} + e^-$. Five iron(II) ions supply the five electrons that one permanganate needs, so the mole ratio is _____.

Change volumes to _____ first: divide millilitres by 1000. So 20.00 mL is _____ L and 25.00 mL is 0.02500 L. Then amount = concentration × volume.

The end point is the first _____. It shows all the iron(II) has reacted. The mole ratio comes from the _____ of the balanced equation, not from 1 to 1.

Example. A 25.00 mL sample of iron(II) solution needs 20.00 mL of 0.0200 mol/L MnO_4^- solution in acid. Find $[Fe^{2+}]$. Given $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ and $Fe^{2+} \rightarrow Fe^{3+} + e^-$.

Work:

Answer: _____

Try it. A 20.00 mL sample of iron(II) solution needs 30.00 mL of 0.0100 mol/L MnO_4^- solution in acid. Find $[Fe^{2+}]$. Use $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$.

Work:

Answer: _____

Slide 5 of 8 · Method: how to choose the method

Step 1. Read what is _____ and what is asked. Do this before you touch a calculator.

Step 2. Sort the problem. A voltage or direction uses the _____. Current and time use _____. A reacting volume uses a _____.

Step 3. Run that method’s steps. Use the matching method slide from this unit.

Step 4. Check the units and the digits. Round _____, at the end.

Example. Use the method on a 25.00 mL sample of iron(II) solution that needs 20.00 mL of 0.0200 mol/L MnO_4^- in acid. Find $[Fe^{2+}]$.

Work:

Answer: _____

Try it. Use the method on 3.00 A for 10.0 minutes through $Ag^+(aq)$ with a silver cathode. M(Ag) = 107.87 g/mol. Choose the method and find the mass of silver.

Work:

Answer: _____

Slide 6 of 8 · Your turn: choose, then solve

Name the method first. Cell A gives table values and asks for a voltage, so use the _____. Cell B gives current and time and asks for a mass, so use _____.

For cell A, zinc has the lower E° (−0.76 V), so zinc is the _____. Zinc gives 2 electrons and each silver ion takes 1, so _____ the silver half.

$Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$. $E°cell = 0.80 - (-0.76) =$ _____. This is positive, so the cell is _____. Do not double the silver value.

For cell B, 30.0 min × 60 = _____. Sodium ions are reduced at the cathode: $Na^+ + e^- \rightarrow$ _____, a ratio of 1 to 1. Write the unit with each answer.

Example. Cell A is a zinc and silver cell: $E°(Zn^{2+}/Zn) = -0.76$ V and $E°(Ag^+/Ag) = +0.80$ V. Cell B is molten NaCl with 2.00 A for 30.0 min. Choose the method for each. Find E°cell for cell A and the mass of sodium for cell B. Use $F = 9.65 \times 10^4$ C/mol e^- and M(Na) = 22.99 g/mol.

Work:

Answer: _____

Try it. Cell C is an iron and silver cell: $E°(Fe^{2+}/Fe) = -0.45$ V and $E°(Ag^+/Ag) = +0.80$ V. Cell D is molten NaCl with 2.50 A for 20.0 min. Choose the method for each. Find E°cell for cell C and the mass of sodium for cell D. Use M(Na) = 22.99 g/mol.

Work:

Answer: _____

Slide 7 of 8 · Corrosion, industry and batteries

Iron rusts because it is _____: $Fe \rightarrow Fe^{2+} + 2e^{-}$. A metal with a lower reduction value, like magnesium (−2.37 V), is a stronger _____ than iron (−0.45 V).

Join magnesium to iron. The magnesium is the _____ and is used up, so it is a sacrificial anode. The iron is protected as the _____.

In electroplating, the object to plate is the _____. In refining, the impure metal is the _____, so it dissolves, and pure metal collects at the cathode.

Every process follows one rule: _____ at the anode and reduction at the _____. A good battery balances voltage, mass, cost, lifetime and disposal.

Example. A steel pipe in soil must be protected from rust. Given $E°(Mg^{2+}/Mg) = -2.37$ V and $E°(Fe^{2+}/Fe) = -0.45$ V, explain how a magnesium block protects the pipe. Name which metal is oxidized and which is the cathode.

Work:

Answer: _____

Try it. Impure copper is refined by electrolysis. Name the electrode that is the impure copper. Write the half-reaction at each electrode.

Work:

Answer: _____

Slide 8 of 8 · Redox in industry: bleaching and preserving

Industry bleaches with an _____ agent. Pulp and paper mills use chlorine dioxide or hydrogen peroxide. Textile makers use hydrogen peroxide or hypochlorite.

The oxidizing agent oxidizes the coloured compounds, so they become _____.

A vat dye such as indigo is treated with a _____ agent so that it dissolves. Oxygen in the air then _____ it back to its colour.

Oxygen is an oxidizing agent. It browns cut fruit and makes fats rancid. An antioxidant such as vitamin C is a _____ agent. It reacts with the _____ first, so the food is protected.

Example. A pulp mill bleaches brown wood pulp with hydrogen peroxide. Name the oxidizing agent. Say what it changed and what was oxidized.

Work:

Answer: _____

Try it. Vitamin C is added to cut apple slices so they do not turn brown. Is vitamin C an oxidizing agent or a reducing agent? Explain how it protects the apple.

Work:

Answer: _____

Sketch (draw and label the diagram):

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1. Given the Data Booklet table values $E°(Cu^{2+}/Cu) = +0.34$ V and $E°(Mg^{2+}/Mg) = -2.37$ V, at 1.0 mol/L. Choose the method. Name the anode and find the voltage.

Work:

Final answer (with unit): _____

2. A current of 4.00 A runs for 20.0 min through $Cu^{2+}(aq)$ with a copper cathode. Find the mass of copper that forms. Use M(Cu) = 63.55 g/mol.

Work:

Final answer (with unit): _____

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3. In acid, 20.00 mL of 0.0150 mol/L MnO_4^- reacts with 25.00 mL of an iron(II) solution. Find $[Fe^{2+}]$. Use $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$.

Work:

Final answer (with unit): _____

4. A reaction has a calculated E°reaction of −0.50 V. What kind of cell can make it happen, and what does the cell need?

Work:

Final answer (with unit): _____

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5. A steel pipe in soil must be protected from rust. Name one method. Say why it works, and say which electrode the pipe is.

Work:

Final answer (with unit): _____

6. A spoon is to be plated with silver from a silver nitrate solution. Which electrode is the spoon? Write the half-reaction there. Which terminal of the power supply is it joined to?

Work:

Final answer (with unit): _____

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7. A mill bleaches wood pulp with hydrogen peroxide. What kind of agent is hydrogen peroxide here? What does it do to the coloured compounds?

Work:

Final answer (with unit): _____

8. Challenge: Given a zinc and copper voltaic cell that delivers 0.300 A for 2.00 hours. Data Booklet values: $E°(Zn^{2+}/Zn) = -0.76$ V, $E°(Cu^{2+}/Cu) = +0.34$ V and $M(Zn) = 65.41$ g/mol. This question needs two methods. Find $E°_{cell}$ in volts. Then find the mass of zinc that the anode loses, in grams. Use $F = 9.65 \times 10^4$ C/mol e^-.

Work:

Final answer (with unit): _____