B15 · Investigation: analyze and explain

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

Goals: Set out results in a table and compare them with predictions. Explain a difference with a possible cause and a test. Write a conclusion with a claim, evidence and an explanation.

Name: _____ Date: _____

Slide 1 of 7 · Put the evidence in a table

This is a _____ sample data set. It was not measured by us. A table puts the evidence in _____, with one row for each cell.

The columns are the metal, the predicted voltage, the measured voltage and the _____. The predicted values are calculated from the _____.

The measured values are _____, because they came from a voltmeter. A reader must be able to tell which numbers were seen and which were _____.

A good table has a _____, units in the headings (V) and a note of the controlled conditions, such as _____ solutions.

Example. A given sample set gives four metals joined to copper at 1.0 mol/L. Zinc is 1.10 V predicted and 1.07 V measured, iron 0.79 V and 0.76 V, nickel 0.60 V and 0.57 V, silver 0.46 V and 0.43 V. Organize it in a table.

Work:

Answer: _____

Try it. Another given sample set has a zinc and silver cell with 1.56 V predicted and 1.52 V measured. An iron and silver cell has 1.25 V predicted and 1.21 V measured. Organize it in a table with a title and units.

Work:

Answer: _____

Slide 2 of 7 · Compare prediction and observation

Difference = _____. For zinc, 1.10 − 1.07 = _____ V, and the other three cells also give 0.03 V.

Every measured voltage is _____ than its prediction by the same 0.03 V. A constant gap means something small affects all the cells in the _____.

The order of the voltages also matches: zinc is highest and _____ is lowest. So the data _____ the prediction. We say support, not prove.

It is called the percent difference, or percent error: (predicted − measured) ÷ _____ × 100. For zinc, 0.03 ÷ 1.10 × 100 = 2.7 %, which is _____ with one significant digit.

Example. Given given predicted and measured voltages: zinc 1.10 V and 1.07 V, iron 0.79 V and 0.76 V, nickel 0.60 V and 0.57 V, silver 0.46 V and 0.43 V. Find each difference and describe the pattern. Then find the percent difference for zinc.

Work:

Answer: _____

Try it. A given iron and silver cell has a predicted voltage of 1.25 V and a measured voltage of 1.21 V. Find the difference and the percent difference. Is the measured value higher or lower?

Work:

Answer: _____

Slide 3 of 7 · Explain the difference

Possible causes of a constant gap: the salt bridge adds _____, metal strips can carry a thin _____ coating, and the solutions may not be exactly 1.0 mol/L.

Each cause is only _____, because we have not tested it. Do not claim a cause that was _____.

To test a cause, change _____ and measure again. If we sand the strips and the voltage rises toward the prediction, the oxide was part of the cause.

Temperature also affects voltage. Table values assume 1.0 mol/L solutions, _____ and 101.325 kPa for gases. A good report records the _____ and the concentration.

Example. Every given measured voltage was 0.03 V lower than the table value. Give two possible causes. Describe one test for one of them.

Work:

Answer: _____

Try it. A student suspects the solutions were not exactly 1.0 mol/L. Describe a test. Say what to change, what to measure and what result would support the cause.

Work:

Answer: _____

Slide 4 of 7 · Method: how to analyze and explain results

Step 1. _____ a table with a title, units and predicted and measured columns.

Step 2. Compare prediction and observation. Percent difference = (predicted − measured) ÷ _____ × 100.

Step 3. Explain a gap with one _____ cause and say how you would test it.

Step 4. Separate the _____ from the inference. An observation is seen or measured.

Step 5. Write a _____ that answers the question, with claim, evidence and reason.

Step 6. Name a limitation and an _____, such as repeating trials and averaging.

Example. Use the method on these given results. Zn: predicted 1.10 V, measured 1.07 V. Fe: 0.79 and 0.76. Ni: 0.60 and 0.57. Ag: 0.46 and 0.43.

Work:

Answer: _____

Try it. Use the method on one given result: nickel and copper, predicted 0.60 V, measured 0.57 V. Find the difference and write a claim.

Work:

Answer: _____

Slide 5 of 7 · Identify products from observations

In the zinc and copper cell, the zinc strip loses mass, so zinc is _____: $Zn \rightarrow Zn^{2+} + 2e^{-}$.

The copper strip gains a _____ coating, so copper ions are reduced: $Cu^{2+} + 2e^{-} \rightarrow$ _____. The blue colour of the solution _____.

An _____ is what we see or measure, such as a mass change, a coating or a colour. An _____ is a conclusion drawn from observations.

Zinc ions are colourless, so Zn^{2+} is _____, not seen. Together the evidence supports $Zn + Cu^{2+} \rightarrow$ _____.

Example. In a zinc and copper cell, the zinc strip gets thinner. The copper strip gets thicker with a reddish-brown coating. The blue solution fades. Name the products. Sort the statements into observations and inferences.

Work:

Answer: _____

Try it. An iron nail is placed in blue copper(II) sulfate solution. The nail gets a reddish-brown coating and the blue colour fades. Name one observation and one inference. Write the cell reaction.

Work:

Answer: _____

Slide 6 of 7 · Your turn: judge the nickel and copper result

A conclusion has three parts: the _____, the evidence and a possible _____ for the gap.

Compare the voltages. Supplied: predicted 0.60 V and measured 0.57 V, a difference of _____ V. The nickel strip lost mass and the copper strip gained a coating, which fits a nickel _____.

The reaction is Ni + Cu^{2+} → _____. Salt bridge resistance or oxide on the nickel could lower the voltage, but we write this as _____ because it was not tested.

A _____ is a weakness in how the data were collected. One trial does not show the variation. Repeat _____ trials and average, and clean the strips.

Example. Given a given nickel and copper result: predicted 0.60 V and measured 0.57 V. The nickel strip lost mass and the copper strip gained a coating. Write a conclusion with a claim, evidence and a possible explanation. Add one limitation and one improvement.

Work:

Answer: _____

Try it. Given a given iron and copper result: predicted 0.79 V and measured 0.76 V. The iron strip lost mass and the copper strip gained a coating. Write a claim, the evidence, the reaction and one improvement.

Work:

Answer: _____

Slide 7 of 7 · Evaluate a battery design

Cells in a row add voltages. To find the battery voltage, multiply one cell by the _____. Three cells at the given 1.07 V give 3 × 1.07 = _____.

Voltage is only one part of the evidence. We also judge mass, cost, _____, the risk of _____, and safety and disposal.

Used batteries contain metals such as zinc, lead or cadmium that harm soil and water, so they are collected for _____. A rechargeable cell makes less _____, but recycling costs energy.

A fair fuel cell presentation states the purpose, the half-reactions, the _____ and the _____. A hydrogen fuel cell gives about _____ per cell.

Example. A team builds a battery from three zinc and copper cells in a row. The given measured voltage of one cell is 1.07 V. Find the battery voltage. Name two other things to judge, and say what should happen to the used battery.

Work:

Answer: _____

Try it. A battery has five cells in a row, each with a given measured voltage of 1.07 V. Find the battery voltage. Give one benefit and one issue of recycling the used battery.

Work:

Answer: _____

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1. Given a result for an iron and copper cell: predicted 0.79 V, measured 0.74 V. Find the difference. The order of the voltages matches the table. Does the result support the prediction?

Work:

Final answer (with unit): _____

2. Name three things a good table of results includes.

Work:

Final answer (with unit): _____

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3. Every measured voltage is lower than the predicted one. Give two possible causes. Describe a test for one of them.

Work:

Final answer (with unit): _____

4. A copper strip is put in silver nitrate solution. It gains a grey coating and the solution turns blue. Name the observations and give one inference.

Work:

Final answer (with unit): _____

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5. In one trial, a measured voltage is 0.10 V lower than predicted. Give one limitation of the investigation and one improvement.

Work:

Final answer (with unit): _____

6. A battery has four cells in a row. Each cell measures 1.07 V. Find the battery voltage. Name one thing to do with the used battery.

Work:

Final answer (with unit): _____

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7. Challenge: Given results for three cells. Zn / Cu: predicted 1.10 V, measured 1.04 V. Fe / Cu: predicted 0.79 V, measured 0.73 V. Zn / Fe: predicted 0.31 V, measured 0.25 V. Find the difference for each cell. Describe the pattern. Then give the most likely cause and one test for it.

Work:

Final answer (with unit): _____