B4 · Predict reactions and investigate

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

Use test results and the Data Booklet reduction table to predict direction, then judge an investigation’s conclusions.

Name: _____ Date: _____

1. Evidence and strength

Separate observations from their explanation

Balancing cannot tell us which way a reaction goes. $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ balances, and so does its reverse. A balanced equation does not by itself prove a _____. Spontaneous means it goes on its own. It does not mean fast.

Here are two example test results. Your class did not measure them. A strip of zinc in a Cu^{2+} solution gets a copper coating. A strip of copper in an Ag^{+} solution gets a silver coating. A new metal coating is evidence that dissolved ions _____ to become metal. The electrons came from the metal that dissolved.

So a metal that gives electrons to another metal’s ions is the stronger reducing agent. The two comparisons link through copper. Reducing agents rank _____. The matching ions run the other way: oxidizing agents rank _____. A metal and its ion have different roles.

On the diploma: build the order from the pairs, and say which metal was the reducing agent in each pair. Write the exact formula, such as Ag^{+}, not just silver.

Watch: What you would see: bubbles of hydrogen gas (Alberta Chemistry Teacher, “Chemistry 30 - Predicting redox reaction from species in the reduction table”, 11:01)

Watch: Observations to report: bubbles, pop test, litmus (Alberta Chemistry Teacher, “Chemistry 30 - Example: predicting redox reaction and observations of reactants and products”, 12:03)

Watch: What a falling H^{+} does to the pH (Alberta Chemistry Teacher, “Chemistry 30 - Example: predicting redox reaction and observations of reactants and products”, 12:22)

Read a reduction row

Every row in the Alberta Chemistry 30 Data Booklet table of standard reduction potentials is written as a reduction. The electrons are on the _____. The oxidizing agents are on the left, and the strongest is at the top. The reducing agents are on the right, and the strongest is at the bottom. A metal on the right side of a row can act as a reducing agent, but only when you read that row _____.

An oxidizing agent reacts spontaneously with a reducing agent that is below it in the table. Ag^{+} is above Cu, so they react. Zn^{2+} is below Cu, so they do not. That is why a copper container can hold a Zn^{2+} solution.

You can only choose substances that are really in the beaker. List every ion, any metal, and water. An acidic or “acidified” solution also has H^+, and a basic solution has OH^-. A strong oxidizing agent elsewhere in the booklet is not in your beaker. It is like picking a team from the people who showed up. Choose the strongest _____ and _____ from what is in the beaker.

Label the diagram with the order of reducing agents and the order of oxidizing agents. These are example results, not measurements from a class experiment.

On the diploma: use the substances given in the question, not every row of the table.

Watch: The forward arrow in the table is the reduction (Alberta Chemistry Teacher, “Chemistry 30 - Predicting redox reaction from species in the reduction table”, 2:44)

Watch: Flip the row to write the oxidation (Alberta Chemistry Teacher, “Chemistry 30 - Predicting redox reaction from species in the reduction table”, 3:10)

Zn in Cu^{2+}: copper coating. Cu in Ag^+: silver coating.

Metal donors, strongest first: _____

Ion acceptors, strongest first: _____

Example results. Your class did not measure them.

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2. What the table values mean

Energy per charge, measured from one starting point

The symbol E means _____, measured in volts. The small ° means _____: 1.0 mol/L, 25.00 °C and 101.325 kPa.

A voltage is the _____. One volt means _____, and a coulomb is a unit of electric charge. For 150 J moved by 100 C, 150 ÷ 100 = _____. Double both and 300 ÷ 200 is still _____.

Every table value is measured from the same starting point, the hydrogen half-reaction, $2H^+ + 2e^- \rightarrow H_2$, which is given _____. Each half-reaction is printed as a _____. A more positive value means a stronger pull on electrons under table conditions.

A table value is not a voltage you could read from one beaker. Voltage compares a _____. In this lesson, putting a metal in a solution gives us a prediction only. It does not measure the voltage of a real cell.

On the diploma: remember the table lists reductions only. Changing a coefficient never changes E°.

Pick the roles first, then subtract

Use E°reaction = E° of the _____ minus E° of the _____. We subtract because the reducing agent's half runs _____. Do not just take larger minus smaller.

A positive answer means the written direction is spontaneous under standard conditions. A negative answer means _____ is spontaneous. It tells you nothing about _____. Doubling the amounts does not change the energy per charge, so never multiply E° by the coefficients.

On the diploma: a common wrong option gives Cu + Zn^{2+} a positive E° by subtracting in the wrong order. Check which one is the reducing agent first.

Watch: List everything that is present (Alberta Chemistry Teacher, "Chemistry 30 - Predicting redox reaction from species in the reduction table", 0:03)

Watch: Label the oxidizing and reducing agents (Alberta Chemistry Teacher, "Chemistry 30 - Predicting redox reaction from species in the reduction table", 1:33)

Watch: Find the best of each (Alberta Chemistry Teacher, "Chemistry 30 - Predicting redox reaction from species in the reduction table", 2:24)

A mixture changes the choice, not the method

Suppose a beaker holds Zn(s), Cu(s), Ag^+ and Cu^{2+}. Use only what is present. The strongest reducing agent is _____ and the strongest oxidizing agent is _____. Choose them before you write any equation.

The reaction is $Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag$. $E° = +0.80 - (-0.76) =$ _____. Cu and Cu^{2+} are still in the mixture, but they are not part of this _____.

This predicts which reaction the strongest pair starts with. It does not tell you the final mixture, or the order other reactions would follow.

Watch: Zinc in hydrochloric acid: list everything present (Alberta Chemistry Teacher, “Chemistry 30 - Predicting redox reaction from species in the reduction table”, 6:02)

Watch: Watch for pairs such as chloride and water (Alberta Chemistry Teacher, “Chemistry 30 - Predicting redox reaction from species in the reduction table”, 9:37)

Watch: Build the list from a longer formula list (Alberta Chemistry Teacher, “Chemistry 30 - Example: predicting redox reaction and observations of reactants and products”, 0:36)

Watch: Tin(II) is both an oxidizing and a reducing agent (Alberta Chemistry Teacher, “Chemistry 30 - Example: predicting redox reaction and observations of reactants and products”, 2:22)

Watch: The common mistake: missing tin(II) as a reducing agent (Alberta Chemistry Teacher, “Chemistry 30 - Example: predicting redox reaction and observations of reactants and products”, 7:42)

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3. Predict, then test the claim

Table values

From the Alberta Chemistry 30 Data Booklet, printed as reductions: Ag^+/Ag _____; Cu^{2+}/Cu _____; Zn^{2+}/Zn _____. These hold at standard table conditions, which are 1.0 mol/L solutions at 25.00 °C. A more positive value means a stronger pull on electrons.

For the reaction as written, E°reaction = E° of the _____ minus E° of the _____. We subtract because the reducing agent runs its table row backwards, as an oxidation. A positive result means the written direction is spontaneous. A negative result means the reverse is spontaneous.

For $Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$, Ag^+ is the oxidizing agent and Cu is the reducing agent: +0.80 - (+0.34) = _____. A volt is one joule of energy per coulomb of charge, so it is a ratio. Do not multiply E° when you multiply a half-reaction's coefficients.

On the diploma: check which value is the oxidizing agent's and which is the reducing agent's before you subtract.

Direction matters

For the proposed $Cu + Zn^{2+} \rightarrow Cu^{2+} + Zn$, Zn^{2+} is the oxidizing agent and Cu is the reducing agent: -0.76 - (+0.34) = _____. Always taking larger minus smaller skips the choice of reducing agent and oxidizing agent. It can answer the wrong direction.

The negative sign means the reverse, Zn with Cu^{2+}, is spontaneous at +1.10 V. The sign tells direction, not speed. No visible change in a short trial is _____, because the reaction might be too slow to see.

On the diploma: a sign-flipped answer is a common wrong option, so match the sign to the reducing agent and the oxidizing agent.

Watch: The spontaneity rule: oxidizing agent above reducing agent (Alberta Chemistry Teacher, "Chemistry 30 - Predicting redox reaction from species in the reduction table", 4:59)

Watch: Below means it does not happen by itself (Alberta Chemistry Teacher, "Chemistry 30 - Predicting redox reaction from species in the reduction table", 5:18)

Watch: Check the spontaneity rule at the end (Alberta Chemistry Teacher, "Chemistry 30 - Example: predicting redox reaction and observations of reactants and products", 10:09)

A fair comparison and a supported conclusion

In a fair test, change one metal-ion pair at a time. Keep the concentration, volume, strip size, temperature and time _____. Add a _____: a test where nothing should happen, such as Cu in Cu^{2+}.

A good conclusion gives a claim, then the evidence, then an _____. Name the metal, the ion that changed and who gave the electrons. The simulation follows fixed rules, so running it again adds no new _____. It does not test hands-on lab skill.

On the diploma: tell an observation, such as seeing a deposit, from an inference, such as saying a metal is the stronger reducing agent. Cite the actual comparisons in your answer.

B4 · Practice

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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.

B4-P01 · Easy · In the reaction $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$, name the reducing agent and the oxidizing agent. Which metal is the stronger reducing agent, Zn or Cu?

B4-P02 · Easy · Test results: Zn gives electrons to Cu^{2+}, and Cu gives electrons to Ag^{+}. Put Zn, Cu and Ag in order as reducing agents, strongest first. Say which two results support your order.

B4-P03 · Easy · The metals are in the order Zn > Cu > Ag as reducing agents. Put their ions, Ag^{+}, Zn^{2+} and Cu^{2+}, in order as oxidizing agents, strongest first.

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B4-P04 · Easy · A beaker contains Cu(s), $Ag^+(aq)$ and nitrate ions. The nitrate ions are spectator ions here. Which two substances could react in a redox reaction? Explain why Zn cannot be one of them.

B4-P05 · Medium · Use these rows from the Data Booklet table of standard electrode potentials: $Ag^+ + e^- \rightarrow Ag$, +0.80 V; $Cu^{2+} + 2e^- \rightarrow Cu$, +0.34 V; $Zn^{2+} + 2e^- \rightarrow Zn$, -0.76 V. The conditions are standard: 25 °C and 1.0 mol/L solutions. Copper metal is put in a solution of Ag^+. Calculate E° for the reaction and write the balanced net equation. Is the reaction spontaneous?

Optional start: The ion in the solution is the oxidizing agent. The metal strip is the reducing agent.

B4-P06 · Medium · Use these rows from the Data Booklet table of standard electrode potentials: $Ag^+ + e^- \rightarrow Ag$, +0.80 V; $Cu^{2+} + 2e^- \rightarrow Cu$, +0.34 V; $Zn^{2+} + 2e^- \rightarrow Zn$, -0.76 V. The conditions are standard: 25 °C and 1.0 mol/L solutions. Calculate E° for the reaction $Cu + Zn^{2+} \rightarrow Cu^{2+} + Zn$. Is the reaction spontaneous as written?

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B4-P07 · Medium · Use these rows from the Data Booklet table of standard electrode potentials: $Ag^+ + e^- \rightarrow Ag$, +0.80 V; $Cu^{2+} + 2e^- \rightarrow Cu$, +0.34 V; $Zn^{2+} + 2e^- \rightarrow Zn$, -0.76 V. The conditions are standard: 25 °C and 1.0 mol/L solutions. Zinc metal is put in a solution of Ag^+. Write the balanced equation and calculate E°. A student doubles +0.80 V because two Ag^+ are needed. Explain the mistake.

B4-P08 · Medium · A simulation shows the same result every time a test is replayed. Can five replays tell you how much a real experiment changes from try to try? Say what the replays can check, and one thing they cannot measure.

B4-P09 · Challenging · Test results, all under the same conditions: a strip of metal A in B^{2+} solution gets a coating of metal B. A strip of metal B in C^+ solution gets a coating of metal C. Predict what happens when A is put in C^+ solution. Write the balanced equation. A forms A^{2+}. Explain how the two results lead to your prediction.

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B4-P10 · Challenging · Two tests compare Zn in Cu^{2+} solution with Cu in Ag^{+} solution. They use different concentrations, different surface areas and different times. Name three things to keep the same so the comparison is fair. Explain why a test with a metal in a solution of its own ion helps.

B4-P11 · Challenging · Use these rows from the Data Booklet table of standard electrode potentials: $Ag^{+} + e^{-} \rightarrow Ag$, +0.80 V; $Cu^{2+} + 2e^{-} \rightarrow Cu$, +0.34 V; $Zn^{2+} + 2e^{-} \rightarrow Zn$, -0.76 V. The conditions are standard: 25 °C and 1.0 mol/L solutions. A student reports $E° = +1.10$ V for $Cu + Zn^{2+} \rightarrow Cu^{2+} + Zn$, by subtracting -0.76 from +0.34. Explain the mistake. Give the correct value with its sign. Which reaction does +1.10 V really describe?

B4-P12 · Challenging · A lab record says: a clean Cu strip in Ag^{+} solution gets a silver-coloured coating. In a control, Cu in Cu^{2+} solution shows no coating. Write a conclusion about the electrons that the record supports. Give two limits of the evidence.