B5 · Balance redox equations in neutral and basic solution

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

Decide whether H^+, OH^- and H_2O may stay, combine given half-reactions for a basic solution, balance a disproportionation and check every final equation.

Name: _____ Date: _____

1. What may stay in the final equation?

Read the condition first

The reaction happens in water, so first ask what kind of solution it is: acidic, basic or neutral. This is called the condition. Acidic water has extra _____. Basic water has extra _____ instead.

So a final equation for a basic solution should have OH^- and H_2O but no _____. Basic water has almost no spare H^+ to use up.

Neutral water has no extra of either, but it is still water, so H_2O is there. A particle the reaction really makes, such as the H^+ made when Cl_2 reacts with water, _____.

Writing the word “basic” beside $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ changes nothing. The half still takes in $8H^+$, so it is still _____.

On the diploma: the words acidic, basic or neutral tell you what the correct option may contain, so check that first.

Watch: The question says acidic or basic (Tyler DeWitt, “How to Balance Redox Equations in Basic Solution”, 0:00)

H^+ used only for counting

Some H^+ are only counting tools. They show up on both sides and cancel. Given $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$ and $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$. Each half moves _____ electrons, so each is multiplied by _____.

Add the halves. The $2H^+$ and $2e^-$ appear on _____, so they cancel, because nothing real was used up or made. The net equation is $2H_2O_2 \rightarrow$ _____.

Check it. Oxygen is _____ on each side, hydrogen is _____ on each side and charge is _____ on each side.

On the diploma: a correct neutral answer has no leftover counting H^+ or e^-, so scan the options for them.

Watch: H^+ is only a counting tool here (Tyler DeWitt, “How to Balance Redox Equations in Basic Solution”, 7:16)

Watch: Add OH^- to both sides (Tyler DeWitt, “How to Balance Redox Equations in Basic Solution”, 12:56)

Watch: H^+ and OH^- make water (Tyler DeWitt, “How to Balance Redox Equations in Basic Solution”, 13:58)

Watch: Subtract extra H_2O (Tyler DeWitt, “How to Balance Redox Equations in Basic Solution”, 14:28)

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2. Check an answer against its condition

Atoms, charge and the kind of solution

Here is how to check a half-reaction. Given the basic half $ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$. Oxygen is _____ on each side and hydrogen is _____ on each side.

Charge on the left is $-1 + 0 - 2 =$ _____. Charge on the right is $-1 - 2 =$ _____. The two electrons on the left show _____, because electrons are gained.

Last, look at what is in the equation. There is OH^- and H_2O and _____ H^+, so the half fits a basic solution.

Watch: Check atoms and charge at the end (Tyler DeWitt, “How to Balance Redox Equations in Basic Solution”, 16:02)

A balanced equation can still be a wrong answer

Given the acidic net equation $2MnO_4^- + 6H^+ + 5NO_2^- \rightarrow 2Mn^{2+} + 3H_2O + 5NO_3^-$. Atoms and charge _____.

But it contains _____. A question that says “basic solution” needs OH^- and H_2O and no H^+, so this equation is _____.

Last step of every balance: check what is left against the _____, as well as atoms and charge.

On the diploma: a wrong option is often balanced correctly but written for the wrong condition, so always compare it with the condition in the question.

Watch: Acidic answer versus basic answer (Tyler DeWitt, “How to Balance Redox Equations in Basic Solution”, 12:25)

> Basic half: $ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$
>
> Oxygen: left ___; right ___. Hydrogen: left ___; right ___
>
> Charge: left _____; right _____
>
> Contains H^+? _____

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

3. Combine halves and disproportionation

Combine two given half-reactions for a basic solution

Electrons given must equal electrons taken, just like in B3. Given $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ and $2I^- \rightarrow I_2 + 2e^-$. The smallest number that both 3 and 2 divide into is _____.

So multiply the first half by _____ ($2 \times 3 = 6$) and the second by _____ ($3 \times 2 = 6$). Multiply every term, including the H_2O and OH^-.

Add the halves and cancel the _____. Nothing else is the same on both sides, so the net equation is $2MnO_4^- + 4H_2O + 6I^- \rightarrow 2MnO_2 + 3I_2 +$ _____.

The finished equation has OH^- and H_2O and _____ H^+, so it fits a basic solution.

On the diploma: matching the electrons is the first step, and wrong options often come from a wrong multiplier.

Watch: Add the halves and cancel (Tyler DeWitt, “How to Balance Redox Equations in Basic Solution”, 10:53)

Disproportionation in acid

Look at $Cl_2 \rightarrow ClO_3^- + Cl^-$ in acid. This is a disproportionation, which you met in B2: one substance is oxidized and reduced at once. Cl goes 0 to +5 (_____) and 0 to −1 (_____).

The oxidation half is $Cl_2 + 6H_2O \rightarrow 2ClO_3^- + 12H^+ +$ _____. The reduction half is $Cl_2 + 2e^- \rightarrow 2Cl^-$. The reduction half takes 2 electrons and the oxidation half gives 10, so multiply the reduction half by _____. Add the halves and cancel the electrons.

That gives $6Cl_2 + 6H_2O \rightarrow 2ClO_3^- + 12H^+ + 10Cl^-$. Every coefficient divides by _____. The lowest whole-number equation is $3Cl_2 + 3H_2O \rightarrow ClO_3^- + 6H^+ + 5Cl^-$. The charge is _____ on each side.

On the diploma: reduce to the lowest whole numbers at the end.

The same reactant in base

Now the same idea in base. Given $Cl_2 \rightarrow ClO^- + Cl^-$ in base. Chlorine goes from 0 to _____ in ClO^- and from 0 to _____ in Cl^-.

Both halves start with Cl_2: $Cl_2 + 4OH^- \rightarrow 2ClO^- + 2H_2O + 2e^-$ and $Cl_2 + 2e^- \rightarrow 2Cl^-$. Each half moves two electrons, so add them to get $2Cl_2 + 4OH^- \rightarrow 2ClO^- + 2Cl^- + 2H_2O$.

Every coefficient is even, so divide every term by _____. An equation shows a ratio of particles, so this keeps it balanced. The lowest whole-number equation is $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- +$ _____.

On the diploma: a numerical-response question may ask for one coefficient, so simplify before you record it.

B5 · Practice

Balance redox equations in neutral and basic solution | 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.

B5-P01 · Easy · A reaction takes place in basic solution. Which of H^+ and OH^- may remain in the final equation, and which may not? Explain in one sentence.

B5-P02 · Easy · Given neutral water: $Cl_2 + H_2O \rightarrow Cl^- + HOCl + H^+$. Check atoms and charge, and say why the H^+ may stay in the final equation.

B5-P03 · Easy · A student copies $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ and writes “basic solution” above it. Explain why the equation is still acidic.

B5 · Practice

Balance redox equations in neutral and basic solution | Questions 4-6 of 12

B5-P04 · Easy · Given $2H_2O_2 \rightarrow O_2 + 2H_2O$ in neutral water, state the oxidation number of oxygen in H_2O_2, in O_2 and in H_2O. Which change is oxidation and which is reduction?

B5-P05 · Medium · Given basic solution: $ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$ and $Fe(OH)_2 + OH^- \rightarrow Fe(OH)_3 + e^-$. Write the lowest whole-number net equation.

B5-P06 · Medium · Given basic solution: $BrO_3^- + 3H_2O + 6e^- \rightarrow Br^- + 6OH^-$ and $2I^- \rightarrow I_2 + 2e^-$. Write the lowest whole-number net equation.

B5 · Practice

Balance redox equations in neutral and basic solution | Questions 7-9 of 12

B5-P07 · Medium · A question asks for the net equation in basic solution. A student gives $Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 7H_2O + 3I_2$. It balances. Why is it not a correct answer?

B5-P08 · Medium · Check $Zn + 2OH^- + 2H_2O \rightarrow Zn(OH)_4^{2-} + H_2$ for atoms and charge. State whether it fits a basic solution.

B5-P09 · Challenging · Given basic solution: $ClO^- \rightarrow ClO_3^- + Cl^-$. The oxidation half is $ClO^- + 4OH^- \rightarrow ClO_3^- + 2H_2O + 4e^-$ and the reduction half is $ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$. Write the lowest whole-number net equation.

B5 · Practice

Balance redox equations in neutral and basic solution | Questions 10-12 of 12

B5-P10 · Challenging · A student gives $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$ as a half for a basic solution. Atoms and charge balance. Why is it not correct?

B5-P11 · Challenging · Given basic solution: reduction $ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$ and oxidation $2I^- \rightarrow I_2 + 2e^-$. Write the lowest whole-number net equation.

B5-P12 · Challenging · Given basic solution: $Br_2 \rightarrow BrO_3^- + Br^-$. The oxidation half is $Br_2 + 12OH^- \rightarrow 2BrO_3^- + 6H_2O + 10e^-$ and the reduction half is $Br_2 + 2e^- \rightarrow 2Br^-$. Write the lowest whole-number net equation.