B5 · Balance redox equations in neutral and basic solution

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

Goals: Decide whether H^+, OH^- and H_2O may stay in an acidic, neutral or basic equation. Balance a redox equation for a basic solution, with the half-reactions given or not given. Check every final equation against the kind of solution in the question.

Name: _____ Date: _____

Slide 1 of 10 · The solution decides what may stay

First read the _____: acidic, neutral or basic. It decides whether H^+, OH^- or H_2O may stay in the final equation.

An acidic equation may contain H_2O and _____. A basic equation may contain H_2O and _____ and should contain no H^+.

The half $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ takes in $8H^+$, so it describes an _____ solution. Writing "basic" beside it changes nothing.

In neutral water, H^+ or OH^- may stay only if the reaction _____ it, as in $Cl_2 + H_2O \rightarrow Cl^- + HOCl + H^+$.

Example. Given $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$. Could this half-reaction be used for a basic solution? Explain using what is in the equation.

Work:

Answer: _____

Try it. Given neutral water: $Cl_2(g) + H_2O(l) \rightarrow Cl^-(aq) + HOCl(aq) + H^+(aq)$. Check atoms and charge, and give the oxidation number of chlorine in Cl_2, Cl^- and $HOCl$.

Work:

Answer: _____

Slide 2 of 10 · Neutral water: hydrogen peroxide breaks down

In H_2O_2 oxygen is _____. In H_2O it is -2 and in O_2 it is 0. One reactant that is both oxidized and reduced shows _____.

Oxidation: $H_2O_2 \rightarrow O_2 + 2H^+ +$ _____. Reduction: $H_2O_2 + 2H^+ + 2e^- \rightarrow$ _____.

Each half moves 2 electrons, so multiply each half by _____ and add them.

The $2H^+$ and $2e^-$ are on both sides and cancel, so they were only _____ H^+. Final equation: $2H_2O_2 \rightarrow O_2 + 2H_2O$.

Example. Given neutral water: H_2O_2 breaks down into H_2O and O_2. Write the two halves, the balanced overall equation, and explain why the H^+ cancel.

Work:

Answer: _____

Try it. Given neutral water: $Cl_2 \rightarrow HOCl + Cl^-$. Use the halves $Cl_2 + 2H_2O \rightarrow 2HOCl + 2H^+ + 2e^-$ and $Cl_2 + 2e^- \rightarrow 2Cl^-$. Write the lowest whole-number equation and say whether H^+ cancels.

Work:

Answer: _____

Slide 3 of 10 · Combine two given basic half-reactions

Reduction takes 3 electrons and oxidation gives 2. The smallest number both reach is _____.

Multiply the reduction by _____ and the oxidation by _____. Multiply every term, including H_2O and OH^-.

Add and cancel the _____. H_2O is only on the left and OH^- only on the right, so neither cancels. Never cancel H_2O against OH^-.

Check: Mn 2, I 6, O 12, H 8 and charge −8 on each side. A basic equation has OH^- and H_2O and no _____.

Example. Given basic solution: reduction $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ and oxidation $2I^- \rightarrow I_2 + 2e^-$. Write the lowest whole-number net equation and check it.

Work:

Answer: _____

Try it. Given basic solution: reduction $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ and oxidation $Fe(OH)_2 + OH^- \rightarrow Fe(OH)_3 + e^-$. Write the lowest whole-number net equation and check it.

Work:

Answer: _____

Slide 4 of 10 · Method: how to balance a redox equation in basic solution

Step 1. Read the _____. The solution is basic.

Step 2. Keep the halves as written with _____ and H_2O. Do not add _____.

Step 3. Make the _____ equal.

Step 4. _____ the halves and cancel any e^-, H_2O or OH^- on both sides.

Step 5. Check: no H^+, equal _____ and equal _____.

Example. Use the method on $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ and $2I^- \rightarrow I_2 + 2e^-$. Write the lowest whole-number net equation.

Work:

Answer: _____

Try it. Use the method on $ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$ and $Zn + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$. Write the net equation.

Work:

Answer: _____

Slide 5 of 10 · Your turn: hypochlorite and chromium(III) hydroxide

Reduction takes 2 electrons and oxidation gives 3. The smallest number both reach is 6. Multiply the reduction by _____ and the oxidation by _____.

In $Cr(OH)_3$ the 2 in front multiplies Cr and everything inside the _____.

After adding and cancelling $6e^-$, OH^- is 10 on the left and 6 on the right, so _____OH^- stays on the left. H_2O is 3 left and 8 right, so _____H_2O stays on the right.

Net: $2Cr(OH)_3 + 3ClO^- + 4OH^- \rightarrow 2CrO_4^{2-} + 3Cl^- + 5H_2O$. Check O 13, H 10 and charge _____ on each side.

Example. Given basic solution: reduction $ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$ and oxidation $Cr(OH)_3 + 5OH^- \rightarrow CrO_4^{2-} + 4H_2O + 3e^-$. Write your multipliers, then the lowest whole-number net equation.

Work:

Answer: _____

Try it. Given basic solution: reduction $BrO^- + H_2O + 2e^- \rightarrow Br^- + 2OH^-$ and oxidation $Cr(OH)_3 + 5OH^- \rightarrow CrO_4^{2-} + 4H_2O + 3e^-$. Write your multipliers, then the lowest whole-number net equation.

Work:

Answer: _____

Slide 6 of 10 · No half-reactions given: balance as in acid, then change to basic

When no half-reactions are given for a basic solution, first balance the equation as in _____ (B3).

Then add _____ to both sides, one for each H^+.

Each H^+ joins an OH^- to make _____. Cancel the H_2O that is on both sides.

Check atoms and charge. A basic equation has no _____ in it.

Example. Given basic solution: $ClO^- + I^- \rightarrow Cl^- + I_2$. No half-reactions are given. Write the balanced net equation and check it.

Work:

Answer: _____

Try it. Given basic solution: $ClO^- + Br^- \rightarrow Cl^- + Br_2$. No half-reactions are given. Write the balanced net equation and check it.

Work:

Answer: _____

Slide 7 of 10 · Your turn: permanganate and nitrite in basic solution

Find the changes with _____ first.

Balance each half as in acid, make the _____ equal, add and cancel.

Count the H^+ that are left. Add that many _____ to both sides.

Turn each H^+ and OH^- pair into _____, cancel H_2O on both sides, and check.

Example. Given basic solution: $MnO_4^- + NO_2^- \rightarrow MnO_2 + NO_3^-$. No half-reactions are given. Write the balanced net equation and check it.

Work:

Answer: _____

Try it. Given basic solution: $MnO_4^- + I^- \rightarrow MnO_2 + I_2$. No half-reactions are given. Write the balanced net equation. Then compare it with the equation on slide 3, where the half-reactions were given.

Work:

Answer: _____

Slide 8 of 10 · Balance a disproportionation

In $Cl_2 \rightarrow ClO_3^- + Cl^-$, chlorine goes from 0 to _____ in ClO_3^- and from 0 to _____ in Cl^-. One species both oxidized and reduced is _____.

Oxidation half: $Cl_2 + 6H_2O \rightarrow 2ClO_3^- + 12H^+ +$ _____e^-. Reduction half: $Cl_2 + 2e^- \rightarrow 2Cl^-$.

Multiply the reduction half by _____ to match 10 electrons. Adding gives $6Cl_2 + 6H_2O \rightarrow 2ClO_3^- + 12H^+ + 10Cl^-$.

Every coefficient divides by 2, so the lowest whole-number equation is $3Cl_2 + 3H_2O \rightarrow ClO_3^- + 6H^+ + 5Cl^-$. Divide _____ term.

Example. Given acidic water: $Cl_2 \rightarrow ClO_3^- + Cl^-$. Chlorine is both oxidized and reduced. Construct both halves, combine them and write the lowest whole-number equation.

Work:

Answer: _____

Try it. Given acidic water: $Br_2 \rightarrow BrO_3^- + Br^-$. Bromine is both oxidized and reduced. Use the halves $Br_2 + 6H_2O \rightarrow 2BrO_3^- + 12H^+ + 10e^-$ and $Br_2 + 2e^- \rightarrow 2Br^-$. Write the lowest whole-number equation.

Work:

Answer: _____

Slide 9 of 10 · A disproportionation in basic water

In base, $Cl_2 \rightarrow ClO^- + Cl^-$ is disproportionation. Chlorine goes from 0 to _____ in ClO^- and from 0 to _____ in Cl^-.

Oxidation: $Cl_2 + 4OH^- \rightarrow 2ClO^- + 2H_2O +$ _____. Reduction: $Cl_2 + 2e^- \rightarrow 2Cl^-$.

Both halves move 2 electrons. Add and cancel them: $2Cl_2 + 4OH^- \rightarrow 2ClO^- + 2Cl^- + 2H_2O$.

Every coefficient is even, so divide every term by _____: $Cl_2 + 2OH^- \rightarrow ClO^- + Cl^- + H_2O$. Charge is _____ on each side.

Example. Given basic solution: $Cl_2 \rightarrow ClO^- + Cl^-$. Use the halves $Cl_2 + 4OH^- \rightarrow 2ClO^- + 2H_2O + 2e^-$ and $Cl_2 + 2e^- \rightarrow 2Cl^-$. Write the lowest whole-number equation and check it.

Work:

Answer: _____

Try it. Given basic solution: $Br_2 \rightarrow BrO^- + Br^-$. Use the halves $Br_2 + 4OH^- \rightarrow 2BrO^- + 2H_2O + 2e^-$ and $Br_2 + 2e^- \rightarrow 2Br^-$. Write the lowest whole-number equation and check it.

Work:

Answer: _____

Slide 10 of 10 · Same method, new conditions

Step 1: read the _____. Step 2: combine halves and match electrons. Step 3: cancel only what is the _____ on both sides. Step 4: check what is left against the condition.

Acidic allows H_2O and _____. Basic allows H_2O and _____.

Neutral allows H_2O, plus H^+ or OH^- only if the reaction _____ them.

An equation can balance in atoms and charge and still be the wrong answer if it does not match the _____.

Example. Given $2MnO_4^- + 6H^+ + 5NO_2^- \rightarrow 2Mn^{2+} + 3H_2O + 5NO_3^-$. A question asks for a basic solution. Does the equation balance, and is it a correct final answer?

Work:

Answer: _____

Try it. A question asks for neutral water. Is $2H_2O_2 \rightarrow O_2 + 2H_2O$ a correct final answer? Check atoms, charge and what is left.

Work:

Answer: _____

B5 · Practice

Balance redox equations in neutral and basic solution | Questions 1-2 of 9

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

Work:

Final answer (with unit): _____

2. Given basic solution: reduction $BrO_3^- + 3H_2O + 6e^- \rightarrow Br^- + 6OH^-$ and oxidation $Fe(OH)_2 + OH^- \rightarrow Fe(OH)_3 + e^-$. Write the lowest whole-number net equation.

Work:

Final answer (with unit): _____

B5 · Practice

Balance redox equations in neutral and basic solution | Questions 3-4 of 9

3. 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.

Work:

Final answer (with unit): _____

4. Given neutral water: $Br_2(l) + H_2O(l) \rightarrow Br^-(aq) + HOBr(aq) + H^+(aq)$. Check atoms and charge. Give the oxidation number of bromine in Br_2, in Br^- and in HOBr. Say why H^+ may stay in the equation.

Work:

Final answer (with unit): _____

B5 · Practice

Balance redox equations in neutral and basic solution | Questions 5-6 of 9

5. Given basic solution: $I_2 \rightarrow IO_3^- + I^-$. The oxidation half is $I_2 + 12OH^- \rightarrow 2IO_3^- + 6H_2O + 10e^-$ and the reduction half is $I_2 + 2e^- \rightarrow 2I^-$. Write the lowest whole-number equation.

Work:

Final answer (with unit): _____

6. Explain why the half-reaction $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ cannot be used in a basic solution. Then name what a final equation for a basic solution may contain.

Work:

Final answer (with unit): _____

B5 · Practice

Balance redox equations in neutral and basic solution | Questions 7-8 of 9

7. Given acidic solution: $BrO_3^- + Fe^{2+} \rightarrow Br^- + Fe^{3+}$. No half-reactions are given. Use oxidation numbers to find what is oxidized and what is reduced. Write both half-reactions. Then write the lowest whole-number net equation and check it against the condition.

Work:

Final answer (with unit): _____

8. Given basic solution: $MnO_4^- + Br^- \rightarrow MnO_2 + BrO_3^-$. No half-reactions are given. Use oxidation numbers to find what is oxidized and what is reduced. Balance as in acid. Then change the equation to basic and check it.

Work:

Final answer (with unit): _____

B5 · Practice

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

9. Challenge: Given basic solution: reduction $MnO_4^- + 2H_2O + 3e^- \rightarrow MnO_2 + 4OH^-$ and oxidation $SO_3^{2-} + 2OH^- \rightarrow SO_4^{2-} + H_2O + 2e^-$. Write the lowest whole-number net equation. Then check atoms, charge and the condition.

Work:

Final answer (with unit): _____