B3 · Balance redox equations in acid

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

Goals: Balance a half-reaction for atoms and charge. Balance a half-reaction in acid with H_2O, H^+ and e^-. Join two half-reactions into one net ionic equation.

Name: _____ Date: _____

Slide 1 of 11 · A half-reaction must conserve atoms and charge

A half-reaction must keep atoms and _____ balanced. A reaction cannot create atoms or charge.

In $Al \rightarrow Al^{3+}$, atoms balance (1 Al on each side) but charge does not. The left is 0 and the right is _____.

One electron has charge _____. Add _____ electrons to the right side: $+3 + 3(-1) = 0$.

Electrons on the product side mean _____. Electrons carry charge but no _____.

Example. Given $Al(s) \rightarrow Al^{3+}(aq)$. Add electrons to make a balanced oxidation half-reaction. What must stay equal on both sides?

Work:

Answer: _____

Try it. Given $Sn^{2+}(aq) \rightarrow Sn^{4+}(aq)$. Add electrons to make a balanced half-reaction. Say whether it is oxidation or reduction.

Work:

Answer: _____

Slide 2 of 11 · Match unequal electron counts before adding

$Al \rightarrow Al^{3+} + 3e^-$ gives away 3 electrons. $Cu^{2+} + 2e^- \rightarrow Cu$ takes _____. Electrons given must equal electrons _____.

The lowest common multiple of 3 and 2 is _____. So we need _____ Al and _____ Cu^{2+}.

Multiply every term of a half-reaction, including the _____. A coefficient changes how many particles there are, not the charge on each one.

Add the halves and cancel the $6e^-$, because the same particle is on _____ sides. Check atoms and total charge: _____ on each side.

Example. Given the halves $Al \rightarrow Al^{3+} + 3e^-$ and $Cu^{2+} + 2e^- \rightarrow Cu$. Build the lowest whole-number net ionic equation and verify it.

Work:

Answer: _____

Try it. Given the halves $Zn \rightarrow Zn^{2+} + 2e^-$ and $Fe^{3+} + 3e^- \rightarrow Fe$. Build the lowest whole-number net ionic equation and verify it.

Work:

Answer: _____

Slide 3 of 11 · Your turn: magnesium and silver

$Mg \rightarrow Mg^{2+}$ gives _____ electrons, so the electrons are on the _____.

$Ag^{+} + e^{-} \rightarrow Ag$ takes only 1 electron, so we need _____ Ag^{+} to take 2 electrons: $2Ag^{+} + 2e^{-} \rightarrow 2Ag$.

Scale the halves first. Then add and cancel the _____.

Check the net equation: one Mg and two Ag on each side, and a total charge of _____ on each side.

Example. Given $Mg \rightarrow Mg^{2+}$ and $Ag^{+} \rightarrow Ag$. Write both balanced halves, then the net ionic equation.

Work:

Answer: _____

Try it. Given $Li \rightarrow Li^{+}$ and $Cu^{2+} \rightarrow Cu$. Write both balanced halves, then the net ionic equation.

Work:

Answer: _____

Slide 4 of 11 · Start the complete acidic reaction from its changes

Find oxidation numbers first. In MnO_4^-, four oxygens give −8 and the charge is 1−, so Mn is _____.

Mn goes +7 to +2, so it is _____. Fe goes +2 to +3, so it is _____.

A skeleton is a half-reaction _____. Use the real species, so write MnO_4^-, not Mn^{7+}.

In acidic water we may add _____ for oxygen and _____ for hydrogen. Electrons cannot fix a missing oxygen.

Example. Given acidic water and $MnO_4^- + Fe^{2+} \rightarrow Mn^{2+} + Fe^{3+}$. Find the changes in oxidation number, then write both skeleton halves.

Work:

Answer: _____

Try it. Given acidic water and $ClO_3^- + Sn^{2+} \rightarrow Cl^- + Sn^{4+}$. Find the changes in oxidation number, then write both skeleton halves.

Work:

Answer: _____

Slide 5 of 11 · Build and check the permanganate half

Balance atoms other than O and H first. Then balance O with _____, H with _____ and charge with _____.

MnO_4^- → Mn^{2+} has 4 O on the left and none on the right. Add _____H_2O on the right. They bring 8 H, so add $8H^+$ on the left.

Use whole-particle charge. Left: −1 + 8 = _____. Right: _____. Add $5e^-$ on the left to make both sides +2.

Check: Mn drops from +7 to +2, which is _____. That matches the 5 electrons gained.

Example. Given acidic solution: MnO_4^- → Mn^{2+}. Build the balanced half-reaction. Account for every atom before balancing charge.

Work:

Answer: _____

Try it. Given acidic solution: ClO_3^- → Cl^-. Build the balanced half-reaction and check atoms, charge and the oxidation-number change.

Work:

Answer: _____

Slide 6 of 11 · Show the full sum before cancelling

The iron half is $Fe^{2+} \rightarrow Fe^{3+} +$ _____. MnO_4^- takes 5 electrons, so use _____ Fe^{2+} for each MnO_4^-.

Multiply every term of the iron half by 5: $5Fe^{2+} \rightarrow 5Fe^{3+} +$ _____. Leave the Mn half alone.

Add the halves before cancelling. Cancel only the $5e^-$. H^+ is only on the left and H_2O only on the right, so _____.

Net: $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$. Charge is _____ on each side. Fe^{2+} is the _____ agent.

Example. Given the halves $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ and $Fe^{2+} \rightarrow Fe^{3+} + e^-$ in acidic solution. Write the overall net ionic equation and check it.

Work:

Answer: _____

Try it. Given the halves $ClO_3^- + 6H^+ + 6e^- \rightarrow Cl^- + 3H_2O$ and $Fe^{2+} \rightarrow Fe^{3+} + e^-$ in acidic solution. Write the overall net ionic equation and check it.

Work:

Answer: _____

Slide 7 of 11 · Water can be a reactant in an oxidation half

Nitrate has one more O than nitrite, so the left side is short one O. Add _____ on the left.

That water brings 2 H to the left, so put _____ on the right. H^+ does not always go on the reactant side.

Before electrons: left charge −1; right −1 + 2 = _____. Add electrons to the more _____ side.

So add _____e^- on the right. Electrons on the product side mean oxidation. N goes from +3 to +5, up 2.

Example. Given acidic water: NO_2^- → NO_3^-. Write the half-reaction and say which earlier decisions change.

Work:

Answer: _____

Try it. Given acidic water: SO_3^{2-} → SO_4^{2-}. Write the half-reaction and check atoms, charge and the oxidation-number change.

Work:

Answer: _____

Slide 8 of 11 · Cancel what is on both sides

The halves take 5 electrons and give 2. The first common total is _____. Multiply the MnO_4^- half by _____ and the NO_2^- half by 5.

After adding, H^+ is on both sides: 16 on the left and 10 on the right. The net is _____ H^+ on the left.

H_2O is on both sides too: 5 on the left and 8 on the right. The net is _____ H_2O on the right.

Cancel only the _____ of the same particle. Net: $2MnO_4^- + 6H^+ + 5NO_2^- \rightarrow 2Mn^{2+} + 3H_2O + 5NO_3^-$, with charge -1 on each side.

Example. Given acidic halves $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ and $NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$. Write the lowest whole-number net equation.

Work:

Answer: _____

Try it. Given acidic halves $ClO_3^- + 6H^+ + 6e^- \rightarrow Cl^- + 3H_2O$ and $NO_2^- + H_2O \rightarrow NO_3^- + 2H^+ + 2e^-$. Write the lowest whole-number net equation.

Work:

Answer: _____

Slide 9 of 11 · Method: how to balance a redox equation in acid

Step 1. Find the changes with oxidation numbers. Then write the skeleton _____. Show only the particles that change.

Step 2. Balance each half: atoms other than O and H, then O with _____, then H with _____, then charge with _____.

Step 3. Make the _____ equal. Multiply each half by the smallest whole number that works.

Step 4. _____ the halves. All reactants go on the left and all products on the right.

Step 5. _____ the e^-, H^+ and H_2O that appear on both sides.

Step 6. Check _____ and _____ on both sides. No electrons are left.

Example. Given acidic solution: $MnO_4^- + NO_2^- \rightarrow Mn^{2+} + NO_3^-$. No half-reactions are given. Use the method to write the lowest whole-number net equation.

Work:

Answer: _____

Try it. Use the method on $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ and $Fe^{2+} \rightarrow Fe^{3+} + e^-$. Write the lowest whole-number net equation.

Work:

Answer: _____

Slide 10 of 11 · Your turn: build the dichromate half

Count chromium first. $Cr_2O_7^{2-}$ has _____ Cr, so write $2Cr^{3+}$ on the right.

Seven O on the left need _____ H_2O on the right. These bring 14 H, so add _____ H^+ on the left.

Charge: left −2 + 14 = +12; right 2(+3) = _____. Add _____ e^- on the left to make both sides +6.

Check: each Cr drops from +6 to +3, so two Cr atoms give 2 × 3 = _____ electrons. Atoms: Cr 2, O 7, H 14.

Example. Given acidic water: $Cr_2O_7^{2-} \rightarrow Cr^{3+}$. Write the balanced half-reaction.

Work:

Answer: _____

Try it. Given acidic water: $NO_3^- \rightarrow N_2O$. Write the balanced half-reaction. Check atoms, charge and the oxidation-number change.

Work:

Answer: _____

Slide 11 of 11 · Your turn: the whole method on dichromate and nitrite

When no half-reactions are given, start with _____. They show what is reduced and what is oxidized.

If the number goes down, the element is _____. If it goes up, it is _____.

Write a skeleton half for each change. Then balance each half: other atoms, O with _____, H with _____, charge with _____.

Make the electrons equal, add the halves, _____ what is on both sides, and check atoms and charge.

Example. Given acidic solution: $Cr_2O_7^{2-} + NO_2^- \rightarrow Cr^{3+} + NO_3^-$. No half-reactions are given. Find the changes with oxidation numbers. Then write the balanced net equation and check it.

Work:

Answer: _____

Try it. Given acidic solution: $MnO_4^- + Sn^{2+} \rightarrow Mn^{2+} + Sn^{4+}$. No half-reactions are given. Find the changes with oxidation numbers. Then write the balanced net equation and check it.

Work:

Answer: _____

B3 · Practice

Balance redox equations in acid | Questions 1-2 of 9

1. Balance $Fe^{2+} \rightarrow Fe^{3+}$ as a half-reaction. Add the electrons and check the charge.

Work:

Final answer (with unit): _____

2. Given $Al \rightarrow Al^{3+}$ and $Ag^{+} \rightarrow Ag$. Write the net ionic equation with the lowest whole numbers.

Work:

Final answer (with unit): _____

B3 · Practice

Balance redox equations in acid | Questions 3-4 of 9

3. In acidic solution, balance NO_3^- → NO as a half-reaction.

Work:

Final answer (with unit): _____

4. Given, in acid: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ and $I^- \rightarrow \frac{1}{2}I_2 + e^-$. Write the overall equation with the lowest whole numbers.

Work:

Final answer (with unit): _____

B3 · Practice

Balance redox equations in acid | Questions 5-6 of 9

5. A student writes $MnO_4^- + 8H^+ + 7e^- \rightarrow Mn^{2+} + 4H_2O$. Find the mistake and fix it.

Work:

Final answer (with unit): _____

6. Given the balanced half-reaction $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$. Check the atoms and the charge. Is it an oxidation or a reduction? Explain.

Work:

Final answer (with unit): _____

B3 · Practice

Balance redox equations in acid | Questions 7-8 of 9

7. Given acidic solution: $MnO_2 + Cl^- \rightarrow Mn^{2+} + Cl_2$. 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.

Work:

Final answer (with unit): _____

8. Given acidic solution: $MnO_4^- + H_2S \rightarrow Mn^{2+} + S$. 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.

Work:

Final answer (with unit): _____

B3 · Practice

Balance redox equations in acid | Questions 9-9 of 9

9. Challenge: Given acidic solution: MnO_4^- changes to Mn^{2+} and SO_2 changes to SO_4^{2-}. Build both half-reactions. Then write the lowest whole-number net ionic equation and check atoms and charge.

Work:

Final answer (with unit): _____