Balancing Redox Equations in Basic Solution (Oxidation-Number Method)

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Step 1: Write the unbalanced equation (the "basic" condition is not important at this point).

$$\mathbf{ClO_3^-}(aq) + I_2(aq) \rightarrow \mathbf{IO_3^-}(aq) + \mathbf{Cl^-}(aq)$$

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Step 2: Assign oxidation numbers.

Example: Chlorate ions and iodine react in a basic aqueous solution to produce iodate ions and chloride ions. Write the balanced chemical equation for this redox reaction.

Step 3: Determine the number of electrons gained and lost by the reactants.

Each chlorine atom gains 6 electrons (+5 to –1).
There is one Cl in each ClO_3^-.
Therefore, there is a gain of 6 electrons for every ClO_3^- that reacts.

gain of 6 e^- per ClO_3^-

+5 –2 0 +5 –2 –1

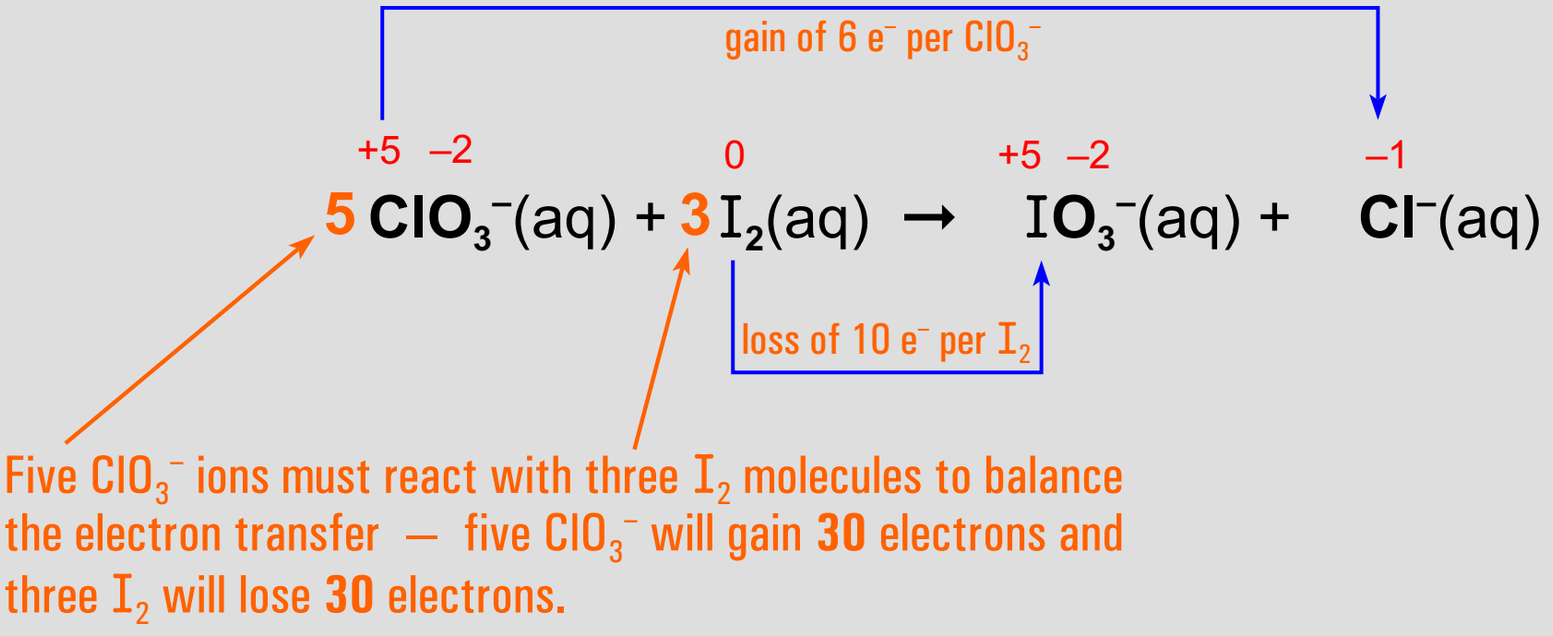
$$ClO_3^-(aq) + I_2(aq) \rightarrow IO_3^-(aq) + Cl^-(aq)$$

loss of 10 e^- per I_2

Each iodine atom loses 5 electrons (0 to +5).
There are two iodine atoms in each I_2.
Therefore, there is a loss of 10 electrons for every I_2 that reacts.

Example: Chlorate ions and iodine react in a basic aqueous solution to produce iodate ions and chloride ions. Write the balanced chemical equation for this redox reaction.

Step 4: Add coefficients to the reactants to balance the electron transfer.



Example: Chlorate ions and iodine react in a basic aqueous solution to produce iodate ions and chloride ions. Write the balanced chemical equation for this redox reaction.

Step 5: Balance all elements except oxygen and hydrogen.

$$5\,ClO_3^-(aq) + 3\,I_2(aq) \rightarrow 6\,IO_3^-(aq) + 5\,Cl^-(aq)$$

Six IO_3^- are needed to balance the iodine atoms.

Five Cl^- are needed to balance the chlorine atoms.

Do not balance oxygen or hydrogen at this point.

Example: Chlorate ions and iodine react in a basic aqueous solution to produce iodate ions and chloride ions. Write the balanced chemical equation for this redox reaction.

Step 6: Balance oxygen using water molecules.

$$3\,H_2O(l) + 5\,ClO_3^-(aq) + 3\,I_2(aq) \rightarrow 6\,IO_3^-(aq) + 5\,Cl^-(aq)$$

There are 15 oxygen atoms on the reactant side and 18 oxygen atoms on the product side.
Three water molecules must be added to the reactant side to balance the oxygen atoms.

Example: Chlorate ions and iodine react in a basic aqueous solution to produce iodate ions and chloride ions. Write the balanced chemical equation for this redox reaction.

Step 7: Balance hydrogen using hydrogen ions.

$$3\,H_2O(l) + 5\,ClO_3^-(aq) + 3\,I_2(aq) \rightarrow 6\,IO_3^-(aq) + 5\,Cl^-(aq) + 6\,H^+(aq)$$

There are 6 hydrogen atoms on the reactant side and no hydrogen atoms on the product side. Six hydrogen ions must be added to the product side to balance the hydrogen atoms.

Example: Chlorate ions and iodine react in a basic aqueous solution to produce iodate ions and chloride ions. Write the balanced chemical equation for this redox reaction.

Step 8: When the reaction occurs in basic solution, hydrogen ions cannot be part of the overall equation and must be eliminated from the balanced equation. This step is not done when the reaction occurs in neutral or acidic solution. This step has three sub-steps.

(a) Add hydroxide ions to both sides of the equation.

$$6\ OH^-(aq) + 3\ H_2O(l) + 5\ ClO_3^-(aq) + 3\ I_2(aq) \rightarrow 6\ IO_3^-(aq) + 5\ Cl^-(aq) + 6\ H^+(aq)$$

$$+\ 6\ OH^-(aq)$$

There are 6 hydrogen ions in the equation. Therefore, add 6 hydroxide ions to both sides of the equation (the ions are added to both sides to keep the equation balanced).

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(b) Combine hydrogen ions and hydroxide ions to form water molecules.

$$6\ OH^-(aq) + 3\ H_2O(l) + 5\ ClO_3^-(aq) + 3\ I_2(aq) \rightarrow 6\ IO_3^-(aq) + 5\ Cl^-(aq) + 6\ H^+(aq) + 6\ OH^-(aq)$$

$$6\ H_2O(l)$$

The 6 hydrogen ions and 6 hydroxide ions on the product side are replaced with 6 water molecules.

Example: Chlorate ions and iodine react in a basic aqueous solution to produce iodate ions and chloride ions. Write the balanced chemical equation for this redox reaction.

Step 8: When the reaction occurs in basic solution, hydrogen ions cannot be part of the overall equation and must be eliminated from the balanced equation. This step is not done when the reaction occurs in neutral or acidic solution. This step has three sub-steps.

(c) Reduce the water molecules if necessary.

$$6\,OH^-(aq) + \cancel{3\,H_2O(l)} + 5\,ClO_3^-(aq) + 3\,I_2(aq) \rightarrow 6\,IO_3^-(aq) + 5\,Cl^-(aq) + \cancel{6\,H_2O(l)}$$

$3\,H_2O(l)$

Three water molecules can be removed from each side

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Step 9: Check the equation for balanced atoms and charge.

$$6\,OH^-(aq) + 5\,ClO_3^-(aq) + 3\,I_2(aq) \rightarrow 6\,IO_3^-(aq) + 5\,Cl^-(aq) + 3\,H_2O(l)$$

Reactants	Products
21 oxygen atoms	21 oxygen atoms
6 hydrogen atoms	6 hydrogen atoms
5 chlorine atoms	5 chlorine atoms
6 iodine atoms	6 iodine atoms
11– charge	11– charge