Balance a Redox Equation in Basic Solution by the Half-Reaction Method Steps

This redox reaction can occur in either an acid or a base:

(1) $IO_3^- + I^- \longrightarrow I_2$

One might mix $KIO_3(aq)$ with $H_2SO_4(aq)$ and $KI(aq)$. The equation would be balanced by the half-reaction method for acidic solutions:

(2) $10\ e^- + 12H^+ + 2\ IO_3^- \longrightarrow I_2 + 6\ H_2O \quad \times 1$

(3) $2\ I^- \longrightarrow I_2 + 2\ e^- \quad \times 5$

(4) $12H^+ + 2\ IO_3^- + 10\ I^- \longrightarrow 6\ I_2 + 6\ H_2O$

The same reaction, equation (1), could take place in basic solution. One might mix $KIO_3(aq)$ with $NaOH(aq)$ and $KI(aq)$. The equation **cannot** be balanced in exactly the same way because there is essentially no H^+ in a basic solution, such as a solution with NaOH. Since acids and bases neutralize each other, they cannot exist together. They react to give water.

(5) $H^+ + OH^- \longrightarrow H_2O$

A solution can have an excess of H^+ or OH^- but not both at once. So the equation (4) is not correct in a basic solution because there is no H^+ reactant in a basic solution. We were able to balance oxygen and hydrogen in an acidic using H_2O and H^+, respectively, but technically we must use H_2O and OH^- in a basic solution to balance oxygen and hydrogen. This is more difficult to do directly since to add either one changes both oxygen and hydrogen. However, we can balance oxygen and hydrogen as if the solution were acidic and then use equation (5) to correct for a basic solution. Since equation (4) is balanced, it will still be balanced if we add **exactly the same molecules** to <u>both</u> sides of the equation. Since equation (4) has 12 H^+ that should not be there, this can be fixed by adding 12 OH^- to both sides of the equation:

(6) $12\ OH^- + 12\ H^+ + 2\ IO_3^- + 10\ I^- \longrightarrow 6\ I_2 + 6\ H_2O + 12\ OH^-$

Then since equation (5) is true, the 12 OH^- + 12 H^+ can be replaced with 12 H_2O:

(7) $12\ H_2O + 2\ IO_3^- + 10\ I^- \longrightarrow 6\ I_2 + 6\ H_2O + 12\ OH^-$

The resulting equation (7) can be improved by canceling 6 H_2O from <u>both</u> sides to give:

(7) $6\ H_2O + 2\ IO_3^- + 10\ I^- \longrightarrow 6\ I_2 + 12\ OH^-$

This is balanced: $6\times2\ H = 12\ H$; $6\ O + 2\times3\ O = 12\ O$; $2\ I + 10\ I = 6\times2\ I$; $2(-) + 10(-) = 12\ (-)$

The overall work for the reaction, $IO_3^- + I^- \longrightarrow I_2$ in basic solution, might look like:

$10\ e^- + 12H^+ + 2\ IO_3^- \longrightarrow I_2 + 6\ H_2O \quad \times 1$

$2\ I^- \longrightarrow I_2 + 2\ e^- \quad \times 5$

$\cancel{12\ OH^-} + \cancel{12\ H^+} + 2\ IO_3^- + 10\ I^- \longrightarrow 6\ I_2 + \cancel{6\ H_2O} + 12\ OH^-$

$12\ H_2O \quad 6H_2O$

$6\ H_2O + 2\ IO_3^- + 10\ I^- \longrightarrow 6\ I_2 + 12\ OH^-$