Balance the reaction $\text{MnO}_4^-(aq) + \text{SO}_3^{2-}(aq) \rightarrow \text{MnO}_2(s) + \text{SO}_4^{2-}(aq)$ in basic solution

**Oxidation states:**

<table>
<thead>
<tr>
<th></th>
<th>$\text{MnO}_4^-$</th>
<th>$\text{SO}_3^{2-}$</th>
<th>$\text{MnO}_2$</th>
<th>$\text{SO}_4^{2-}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxid.</td>
<td>+7, 4(-2)</td>
<td>+4, 3(-2)</td>
<td>+4, 2(-2)</td>
<td>+6, 4(-2)</td>
</tr>
<tr>
<td>electrons</td>
<td></td>
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Therefore, Mn gets reduced (+7 $\rightarrow$ +4) and S gets oxidized (+4 $\rightarrow$ +6)

1) Write down the half reactions (incomplete):

$$\text{MnO}_4^- \rightarrow \text{MnO}_2 \quad \hspace{1cm} \text{(a)}$$

$$\text{SO}_3^{2-} \rightarrow \text{SO}_4^{2-} \quad \hspace{1cm} \text{(b)}$$

2) These are already balanced in Mn and S

3) Balance O in (a) by adding H$_2$O’s to the right-hand-side

$$\text{MnO}_4^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$$

4) Balance H by adding H$^+$ to the left-hand-side

$$\text{MnO}_4^- + 4\text{H}^+ \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$$

5) Balance charge by adding electrons

$$\text{MnO}_4^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$$

6) Convert to basic solution by replacing the H$^+$ with H$_2$O and adding the same number of OH$^-$ ions to the other side

$$\text{MnO}_4^- + 4\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O} + 4\text{OH}^-$$

7) Cancel any extra H$_2$O’s

$$\text{MnO}_4^- + 2\text{H}_2\text{O} + 3\text{e}^- \rightarrow \text{MnO}_2 + 4\text{OH}^-$$

Do the same with the sulfur half reaction to get:

$$\text{SO}_3^{2-} + 2\text{OH}^- \rightarrow \text{SO}_4^{2-} + \text{H}_2\text{O} + 2\text{e}^-$$

8) Combine the two by multiplying the Mn rxn by 2 and the S rxn by 3 and add:

$$2\text{MnO}_4^- + 4\text{H}_2\text{O} + 3\text{SO}_3^{2-} + 6\text{OH}^- + 6\text{e}^- \rightarrow 2\text{MnO}_2 + 8\text{OH}^- + 3\text{SO}_4^{2-} + 3\text{H}_2\text{O} + 6\text{e}^-$$

9) Canceling yields:

$$2\text{MnO}_4^- + \text{H}_2\text{O} + 3\text{SO}_3^{2-} \rightarrow 2\text{MnO}_2 + 2\text{OH}^- + 3\text{SO}_4^{2-}$$