Balancing Redox Equations in Neutral or Acidic Solution (Oxidation-Number Method)

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

$$MnO_4^-(aq) + CH_3OH(aq) \rightarrow MnO_2(s) + CO_2(g)$$

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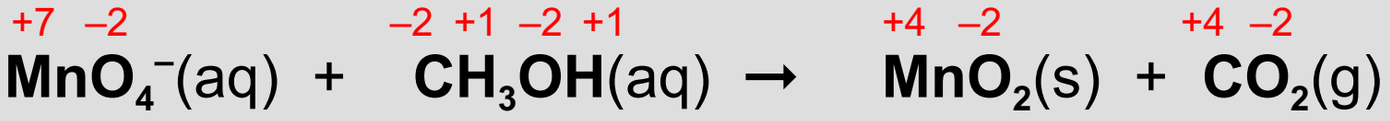
Step 2: Assign oxidation numbers.



Example: In an acidic aqueous solution, permanganate ions and methanol react to produce manganese(IV) oxide and carbon dioxide. Write the balanced chemical equation for this redox reaction.

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

Each manganese atom gains 3 electrons (+7 to +4).
There is one Mn in each MnO_4^-.
Therefore, there is a gain of 3 electrons for every MnO_4^- that reacts.

gain of 3 e^- per MnO_4^-

+7 –2 –2 +1 –2 +1 +4 –2 +4 –2

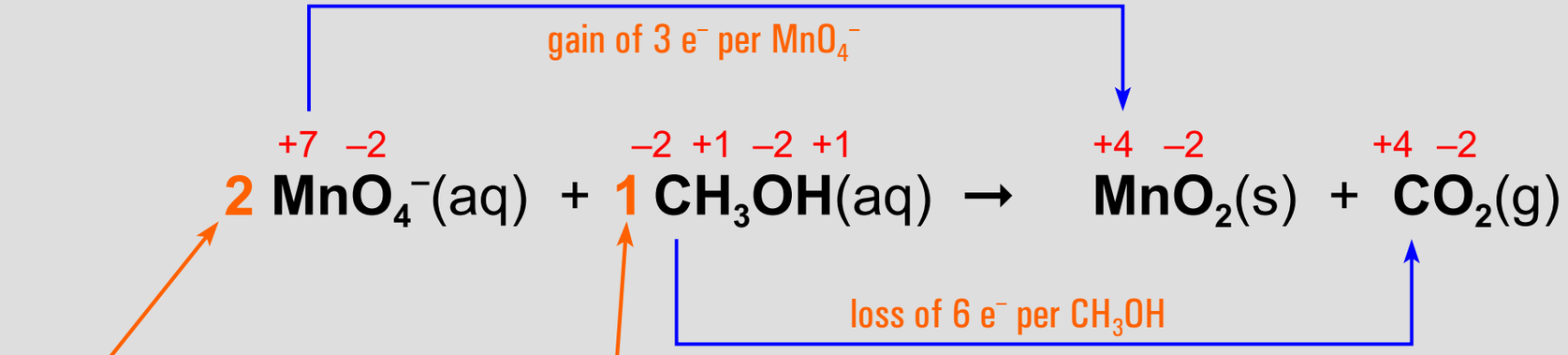
$$MnO_4^-(aq) + CH_3OH(aq) \rightarrow MnO_2(s) + CO_2(g)$$

loss of 6 e^- per CH_3OH

Each carbon atom loses 6 electrons (–2 to +4).
There is one C in each CH_3OH.
Therefore, there is a loss of 6 electrons for every CH_3OH that reacts.

Example: In an acidic aqueous solution, permanganate ions and methanol react to produce manganese(IV) oxide and carbon dioxide. Write the balanced chemical equation for this redox reaction.

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



Two MnO_4^- ions must react with one CH_3OH molecule to balance the electron transfer — two MnO_4^- will gain **6** electrons and one CH_3OH will lose **6** electrons.

(The "1" is not normally written in the equation but is included here for clarity.)

Example: In an acidic aqueous solution, permanganate ions and methanol react to produce manganese(IV) oxide and carbon dioxide. Write the balanced chemical equation for this redox reaction.

Step 5: Balance all elements except oxygen and hydrogen.

$$2\ MnO_4^-(aq) + CH_3OH(aq) \rightarrow 2\ MnO_2(s) + CO_2(g)$$

Two MnO_2 are needed to balance the Mn atoms.
The carbon atoms are already balanced (one on each side).
Do not balance oxygen or hydrogen at this point.

Example: In an acidic aqueous solution, permanganate ions and methanol react to produce manganese(IV) oxide and carbon dioxide. Write the balanced chemical equation for this redox reaction.

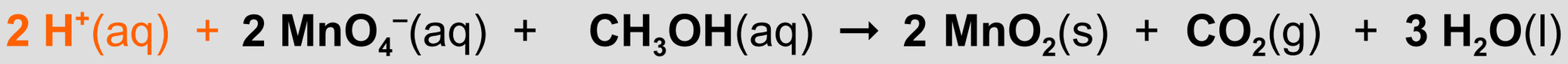
Step 6: Balance oxygen using water molecules.

$$2\ MnO_4^-(aq) + CH_3OH(aq) \rightarrow 2\ MnO_2(s) + CO_2(g) + 3\ H_2O(l)$$

There are 9 oxygen atoms on the reactant side and only 6 oxygen atoms on the product side.
Three water molecules must be added to the product side to balance the oxygen atoms.

Example: In an acidic aqueous solution, permanganate ions and methanol react to produce manganese(IV) oxide and carbon dioxide. Write the balanced chemical equation for this redox reaction.

Step 7: Balance hydrogen using hydrogen ions.



There are 4 hydrogen atoms on the reactant side and 6 hydrogen atoms on the product side.
Two hydrogen ions must be added to the reactant side to balance the hydrogen atoms.

Example: In an acidic aqueous solution, permanganate ions and methanol react to produce manganese(IV) oxide and carbon dioxide. Write the balanced chemical equation for this redox reaction.

Step 8: Check the equation for balanced atoms and charge.