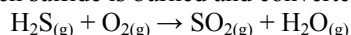


9.2 Balancing Redox Equations

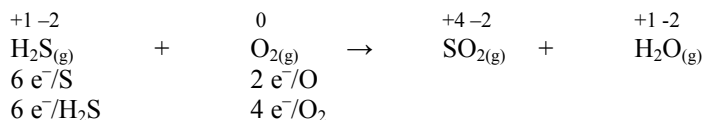
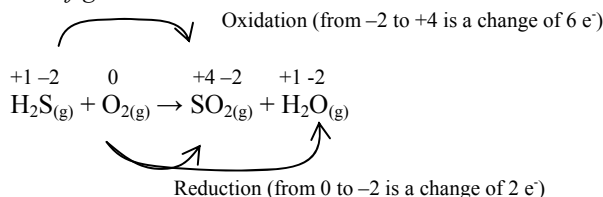
- All redox reactions are electron transfer reactions. This means that electrons that are lost by one particle are the same electrons gained by another.
- Some redox reactions can be balanced by inspection or trial & error, but others can be very difficult to balance due to the complexity of the reaction.

Oxidation Number Method: Reactant side first then balance the product side

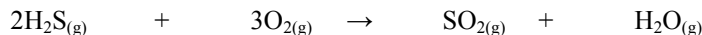
- The total increase in oxidation number for a particular atom/ion must equal the total decrease in oxidation number of another atom/ion.
- E.g. Hydrogen sulfide is burned and converted to sulfur dioxide.



First figure out oxidation numbers

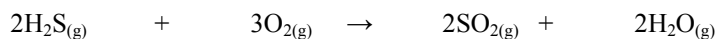


Find the simplest whole number for the coefficients for each molecule.

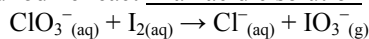


Complete by balancing the products.

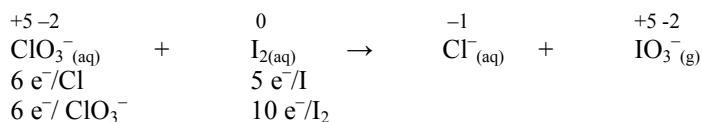
Balance the atoms whose oxidation number has changed. Balance the other atoms after.



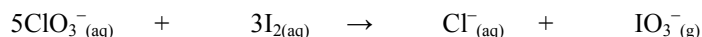
- E.g. Chlorate ions and iodine react in an acidic solution to produce chloride ions and iodate ions.



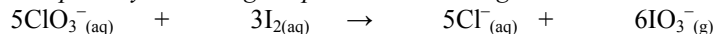
First figure out oxidation numbers



Find the simplest whole number for the coefficients.

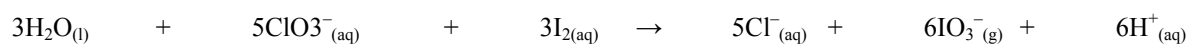
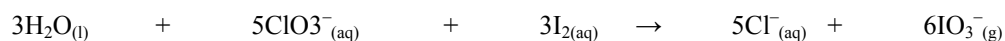


Complete by balancing the products balancing the atoms whose oxidation number has changed.



Problem: oxygen is not balanced 15 on left and 18 on right.

This can be fixed since it is in an acidic solution we get additional oxygen from the autoionization of water and leave the H^+ in the acidic solution. Therefore add H_2O to balance the O and H^+ to balance the H's.



Summary

Copy from page 667

- Step 1 Assign oxidation numbers and identify the atoms/ions whose oxidation numbers change.
- Step 2 Using the change in oxidation numbers, write the number of electrons transferred per atom.
- Step 3 Using the chemical formulas, determine the number of electrons transferred per reactant. (Use the formula subscripts to do this.)
- Step 4 Calculate the simplest whole number coefficients for the reactants that will balance the total number of electrons transferred. Balance the reactants and products.
- Step 5 Balance the O atoms using $H_2O(l)$, and then balance the H atoms using $H^+(aq)$.

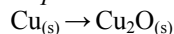
For basic solutions only,

- Step 6 Add $OH^-(aq)$ to both sides equal in number to the number of $H^+(aq)$ present.
- Step 7 Combine $H^+(aq)$ and $OH^-(aq)$ on the same side to form $H_2O(l)$, and cancel the same number of $H_2O(l)$ on both sides.

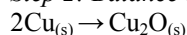
Half Reaction Method

- Balancing of redox reactions using half reactions. The reactions can occur in neutral, acidic, or basic environments. The conditions will change how you answer the question.
- E.g. Copper metal can be oxidized in an *acidic* solution to form copper (I) oxide. What is the half reaction for this process?

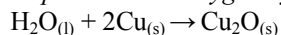
Step 1: write the unbalanced half reactions.



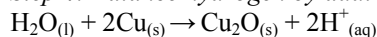
Step 2: Balance any atoms other than oxygen and hydrogen.



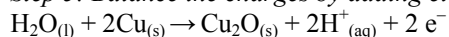
Step 3: Balance oxygen by adding water.



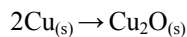
Step 4: Balance hydrogen by adding hydrogen atoms



Step 5: Balance the charges by adding electrons.

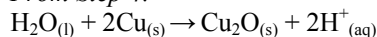


- E.g. Copper metal can be oxidized in a *basic* solution to form copper (I) oxide. What is the half reaction for this process?

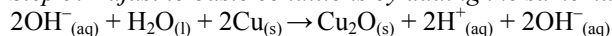


Complete the steps 1-4 above but add the following steps.

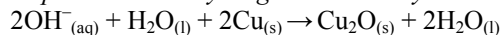
From Step 4:



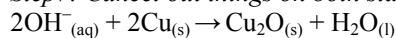
Step 5: Adjust to basic conditions by adding the same number of hydroxide ions as hydrogen ions to both sides.



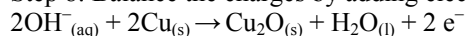
Step 6: Combine hydrogen ions and hydroxide ions.



Step 7: Cancel out things on both sides. (specifically water)

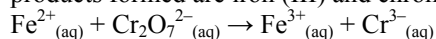


Step 8: Balance the charges by adding electrons.

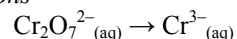
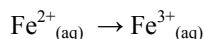


Balancing Redox Equations Using Half Reaction Equations

- E.g. In a chemical analysis, a solution of dichromate ions is reacted with an acidic solution of iron (II) ions. The products formed are iron (III) and chromium (III) ions as shown in the equation. Balance the redox equation.



Split the equation into half reactions



Treat each half separately and balance.

$\text{Fe}^{2+}_{(aq)} \rightarrow \text{Fe}^{3+}_{(aq)} + \text{e}^-$	$\text{Cr}_2\text{O}_7^{2-}_{(aq)} \rightarrow \text{Cr}^{3+}_{(aq)}$
	$\text{Cr}_2\text{O}_7^{2-}_{(aq)} \rightarrow 2\text{Cr}^{3+}_{(aq)}$
	$\text{Cr}_2\text{O}_7^{2-}_{(aq)} \rightarrow 2\text{Cr}^{3+}_{(aq)} + 7\text{H}_2\text{O}_{(l)}$
	$14\text{H}^+_{(aq)} + \text{Cr}_2\text{O}_7^{2-}_{(aq)} \rightarrow 2\text{Cr}^{3+}_{(aq)} + 7\text{H}_2\text{O}_{(l)}$
	$18\text{e}^- + 14\text{H}^+_{(aq)} + \text{Cr}_2\text{O}_7^{2-}_{(aq)} \rightarrow 2\text{Cr}^{3+}_{(aq)} + 7\text{H}_2\text{O}_{(l)}$
number of electrons must be equal	
$18[\text{Fe}^{2+}_{(aq)} \rightarrow \text{Fe}^{3+}_{(aq)} + \text{e}^-]$	
$18\text{Fe}^{2+}_{(aq)} \rightarrow 18\text{Fe}^{3+}_{(aq)} + 18\text{e}^-$	$18\text{e}^- + 14\text{H}^+_{(aq)} + \text{Cr}_2\text{O}_7^{2-}_{(aq)} \rightarrow 2\text{Cr}^{3+}_{(aq)} + 7\text{H}_2\text{O}_{(l)}$
Put the two reactions together and cancel out thing on both sides of the equation.	
$18\text{Fe}^{2+}_{(aq)} \rightarrow 18\text{Fe}^{3+}_{(aq)} + 18\text{e}^-$	
$18\text{e}^- + 14\text{H}^+_{(aq)} + \text{Cr}_2\text{O}_7^{2-}_{(aq)} \rightarrow 2\text{Cr}^{3+}_{(aq)} + 7\text{H}_2\text{O}_{(l)}$	
$18\text{Fe}^{2+}_{(aq)} + 14\text{H}^+_{(aq)} + \text{Cr}_2\text{O}_7^{2-}_{(aq)} \rightarrow 2\text{Cr}^{3+}_{(aq)} + 7\text{H}_2\text{O}_{(l)} + 18\text{Fe}^{3+}_{(aq)}$	