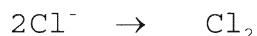
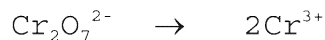


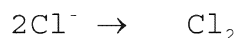
Ion-electron method of balancing oxidation-reduction method

Reaction of dichromate and chlorine in **acidic solution**

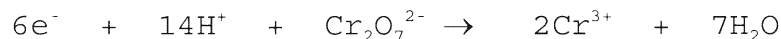
1. Write two skeleton partial reactions and balance atoms other than hydrogen and oxygen.



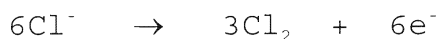
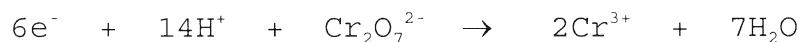
2. Balance H and O atoms by adding H_2O to the side deficient in oxygen and H^+ to the side deficient in hydrogen.



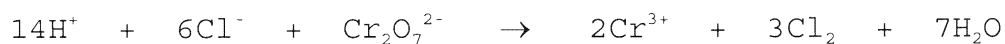
3. Balance each half-reaction electrically using electrons.



4. Obtain the same number of electrons gained by one half-reaction and lost by the other half-reaction by multiplying by the appropriate factors. (In this example, the least common multiple of 6 and 2 is 6 and so the second half-reaction is multiplied by 3.)



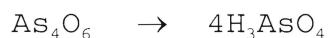
5. Add partial equations to get final equation and cross off identical species on each side.



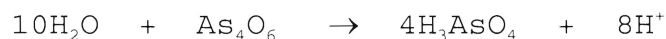
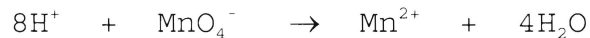
Ion-electron Method/Acid SolutionExample 2

As_4O_6 reacts with MnO_4^- to produce H_3AsO_4 and Mn^{2+}

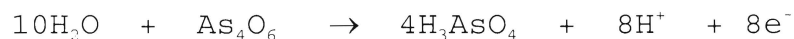
1. Write skeleton partial equations for half reactions.



2. Add H^+ and H_2O .



3. Balance net charges via electrons.



4. Multiply each equation through by appropriate factor to balance electrons gained with electrons lost.



5. Add equations and cancel what is possible from each side.



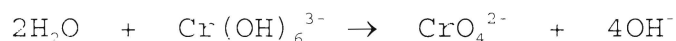
Ion-electron Method/Alkaline Solution

For alkaline solutions, all the steps are the same as in acid solution except the second one. H^+ **cannot** be used. The following reaction takes place in alkaline solution.

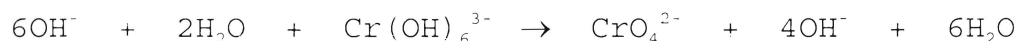


2. For reactions occurring in alkaline solution, OH^- and H_2O are used to balance oxygen and hydrogen. For each oxygen that is needed, 2OH^- ions are added to the side of the partial equation that is deficient, and one H_2O molecule is added to the opposite side. For each hydrogen that is needed, one H_2O molecule is added to the side that is deficient, and one OH^- is added to the opposite side.

In the first partial equation, the right side is deficient by 2 oxygen atoms. We add, therefore, 4OH^- to the right side and $2\text{H}_2\text{O}$ to the left. This addition takes care of oxygen balance only.



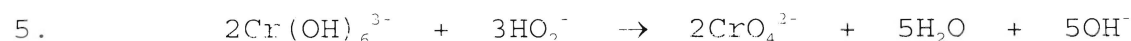
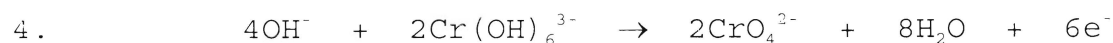
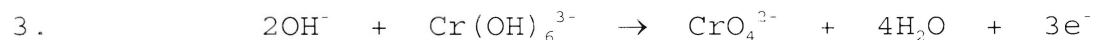
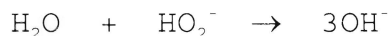
We need (as we originally needed) 6 more hydrogen atoms on the right and therefore add $6\text{H}_2\text{O}$ to the right and 6OH^- to the left.



We can consolidate our additions:

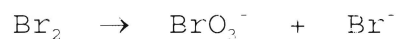


The second partial equation is brought into material balance by the addition of 2OH^- to the right and one H_2O to the left.

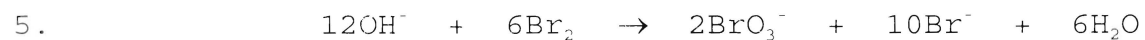
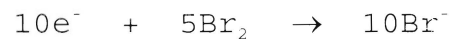
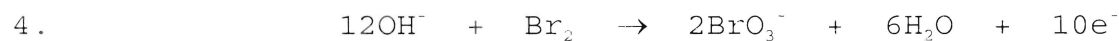
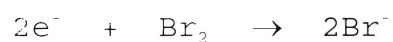
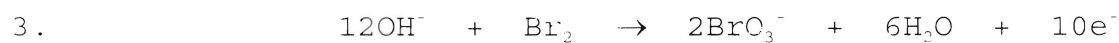
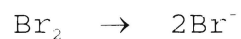
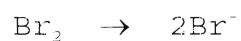


Ion-electron Method/Disproportionation or Auto-Oxidation-Reduction Reactions.

Consider the following skeleton equation for a reaction in alkaline solution.



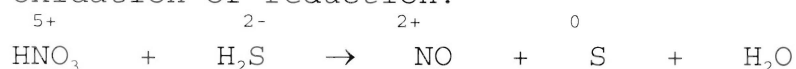
In this reaction, the same substance, Br_2 , is both oxidized and reduced.



Oxidation number method for balancing reactions

For the reaction: $\text{HNO}_3 + \text{H}_2\text{S} \rightarrow \text{NO} + \text{S} + \text{H}_2\text{O}$

- 1) Identify and write oxidation numbers of elements undergoing oxidation or reduction.



- 2) Use coefficients to make the **total** decrease in oxidation number equal to the total increase in oxidation number.

N goes from 5+ to 2+, a change of -3

S goes from 2- to 0, a change of +2

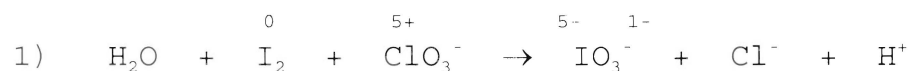
Therefore, the nitrogen compounds take a coefficient of 2 and the sulfur a coefficient of 3.



- 3) Complete by inspection.



- Charge and atoms of each element must balance
- This method may be used for net or ionic equations, in which only those ions and molecules that actually take part in the reaction are shown. For example, the K^+ ion does not take part in the reaction of potassium chlorate, KClO_3 , with iodine and is not shown in the equation.

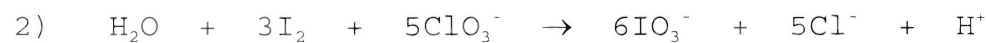


I: 0 to 5+, change of 5+ x 2 (for each atom) = 10+

(Each iodine atom undergoes an increase of 5 so the total change in oxidation number here is 10+)

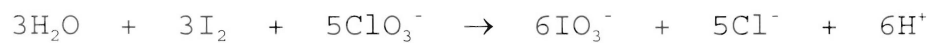
Cl: 5+ to 1-, change of 6- = 6-

Least common multiple is 30



- 3) Ignoring H_2O , there are now 15 oxygen atoms on the left and 18 oxygen atoms on the right. To make up 3 oxygen atoms on the left, $3\text{H}_2\text{O}$ molecules must be indicated. It then

follows that the coefficient of H^+ must be 6 to balance the hydrogens of the H_2O molecules.



An ionic equation must indicate charge balance as well as mass balance. Since the algebraic sum of charges on the left, 5-, equals that of the right, 5-, the equation is balanced.