**Balancing Redox Reactions: Half-Reaction Method**

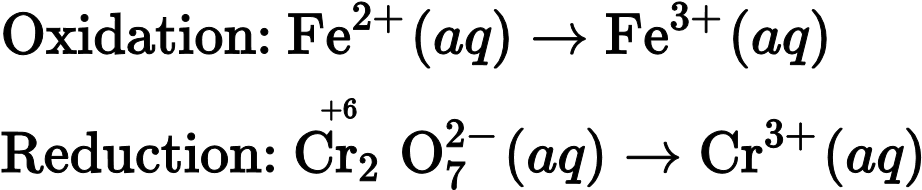
Another method for balancing redox reactions (besides using oxidation states) uses half-reactions. Recall that a half reaction is either the oxidation or reduction that occurs, treated separately. The **half reaction method** works better than the oxidation-number method when the substances in the reaction are in aqueous [solution](https://www.ck12.org/c/physical-science/solution?referrer=crossref). The aqueous solution is typically either acidic or basic, so hydrogen ions or hydroxide ions are present.

In general, the half-reactions are first balanced by atoms separately. Electrons are included in the half-reactions. These are then balanced so that the number of electrons lost is equal to the number of electrons gained. Finally, the two half-reactions are added back together. The example is the oxidation of Fe2+ ions to Fe3+ ions by dichromate (Cr2O72−) in acidic [solution.](https://www.ck12.org/c/physical-science/solution?referrer=crossref) The dichromate ions are reduced to Cr3+ ions.

**Step 1:** *Write the unbalanced ionic equation*.

Notice that the equation is far from balanced, as there are no oxygen atoms on the right side. This will be resolved by the balancing method.

**Step 2:** *Write separate half-reactions for the oxidation and the reduction processes*. Determine the oxidation numbers first, if necessary.



**Step 3:** *Balance the atoms in the half-reactions other than the hydrogen and oxygen*. In the oxidation half-reaction above, the iron atoms are already balanced. The reduction half-reaction needs to be balanced with the chromium atoms.

**Step 4:** *Balance oxygen atoms by adding* [*water*](https://www.ck12.org/c/biology/water?referrer=crossref) *molecules to the appropriate side of the equation*. For the reduction half-reaction above, seven H2O molecules will be added to the product side.

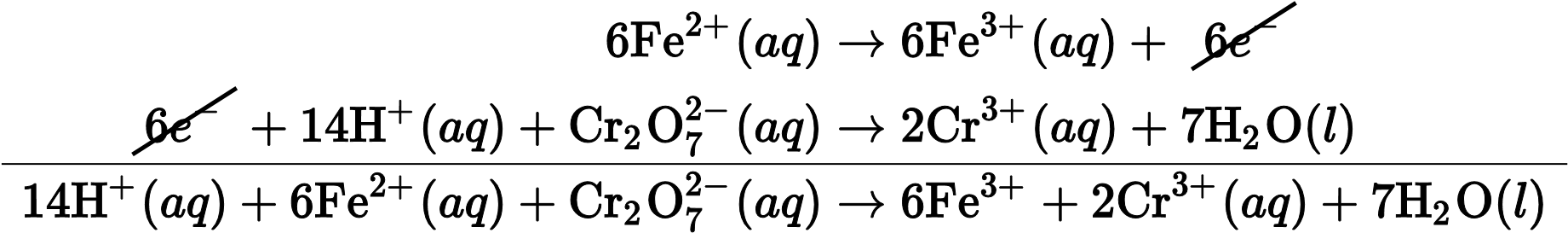
Now the hydrogen atoms need to be balanced. *In an acidic medium, add hydrogen ions to balance*. In this example, fourteen H+ ions will be added to the reactant side.

**Step 5:** *Balance the charges by adding electrons to each half-reaction*. For the oxidation half-reaction, the electrons will need to be added to the product side. For the reduction half-reaction, the electrons will be added to the reactant side. By adding one [electron](https://www.ck12.org/c/physical-science/electron?referrer=crossref) to the product side of the oxidation half-reaction, there is a 2+ total charge on both sides.

There is a total charge of 12+ on the reactant side of the reduction half-reaction (14 – 2). The product side has a total charge of 6+ due to the two chromium ions (2 × 3). To balance the charge, six electrons need to be added to the reactant side.

*Now equalize the electrons by multiplying everything in one or both equations by a coefficient*. In this example, the oxidation half-reaction will be multiplied by six.

**Step 6:** *Add the two half-reactions together. The electrons must cancel. Balance any remaining substances by inspection. If necessary, cancel out H2O* *or H+* *that appear on both sides.*



**Step 7:** *Check the balancing.* In the above equation, there are 14 H, 6 Fe, 2 Cr, and 7 O on both sides. The net charge is 24+ on both sides. The equation is balanced.

# Review

1. Why do you need the unbalanced ionic equation?
2. What does balancing each half-reaction separately tell you?
3. How do you balance hydrogens in an acidic medium?