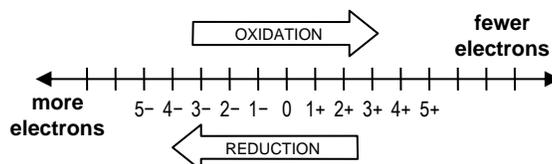




## Balancing Redox Reactions 1: *The Oxidation Number Method*

During **oxidation** (loss of electrons), the oxidation number increases. During **reduction** (gain of electrons), the oxidation number decreases:



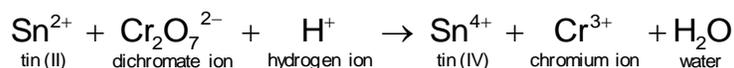
In chemical reactions involving **reduction-oxidation (redox)**, the total number of electrons lost in the oxidation process must equal the total number of electrons gained during the reduction process.

In a redox reaction, the substance that gets oxidized (that loses electrons) is called the **reducing agent** because it reduces the other substance by giving its electrons. The substance that gets reduced (that gains electrons) is called the **oxidizing agent** because it oxidizes the other substance by removing its electrons.

The steps for balancing a redox reaction using the *oxidation number method* are:

- [1] **Assign oxidation numbers** to all atoms in the equation.
- [2] **Identify the atoms which change** oxidation number. Insert temporary coefficients so that there are the same number of atoms on each side. If an element has two different oxidation numbers on one side of the equation, duplicate the source of that element on the other side.
- [3] **Determine the total change** in oxidation numbers for the oxidation and reduction using the coefficients from step 2.
- [4] **Multiply the coefficients** by appropriate factors to make the total loss and gain of electrons the same.
- [5] **Balance the rest of the equation** by inspection.

*Example 1:* Balance the following equation:

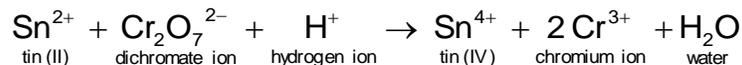


*Solution:* [1] Reagents: Sn: 2+, Cr: 6+, H: 1+, O: 2-  
 Products: Sn: 4+, Cr: 3+, H: 1+, O: 2-



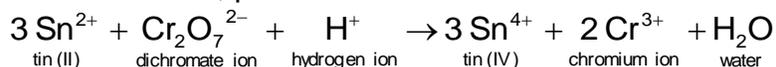
[2] Tin gets oxidized ( $2+ \rightarrow 4+$ ) and chromium gets reduced ( $6+ \rightarrow 3+$ )

Balance chromium:

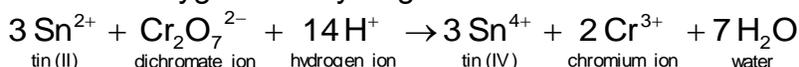


[3] The tin loses 2 electrons total at this stage of balancing, and the chromium gains 6 (3 electrons each).

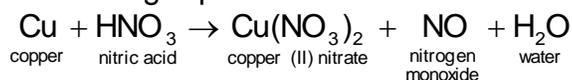
[4] To balance the electrons, put a coefficient of 3 in front of both tin ions:



[5] All that's left is the oxygen and hydrogen:

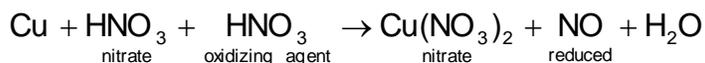


*Example 2:* Balance the following equation:



*Solution:* [1] Reagents: Cu: 0, H: +1, N: +5, O: -2  
Products: Cu: +2, H: +1, N: **+5 & +2**, O: -2

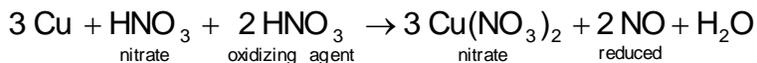
[2] Because nitrogen has different oxidation numbers on the products side, we know some of the nitrate ions stayed intact for the copper (II) nitrate and some reacted to make nitrogen monoxide. We rewrite the equation to reflect this:



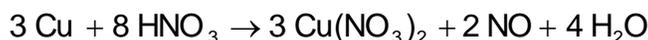
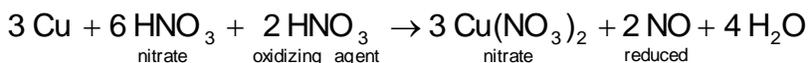
We can treat each of the nitric acids as a source for a different product containing nitrogen, and add them back together at the end. Copper is balanced in this equation, as is reduced nitrogen. We won't look at the nitrates until step [5].

[3] The copper loses 2 electrons at this stage of balancing and the nitrogen gains 3.

[4] Copper needs to be multiplied by 3 and nitrogen by 2 to make a total electronic exchange of 6 electrons:

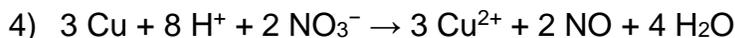
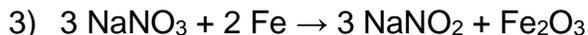
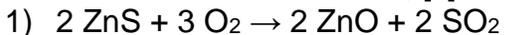


[5] We balance the rest of the equation:

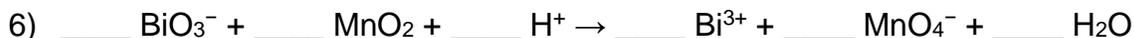
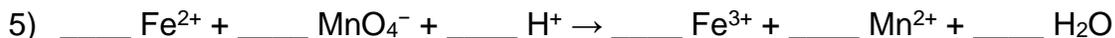
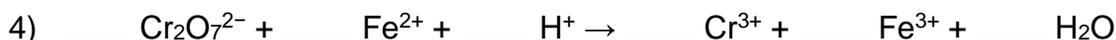
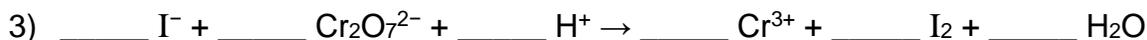
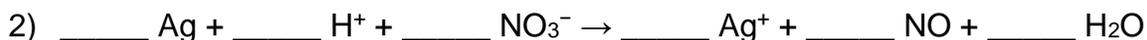
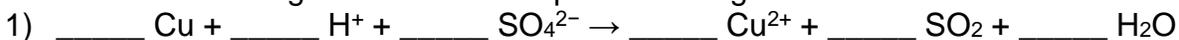


## EXERCISES

A. For each of the following equations, identify [a] the element which was oxidized, [b] the element which was reduced, [c] the oxidizing agent, and [d] the reducing agent.



B. Balance the following redox reaction equations using the oxidation number method:



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## SOLUTIONS

A. (1) S, O, O, S (2) Fe, Cl, Cl, Fe (3) Fe, N, N, Fe (4) Cu, N, N, Cu (5) Mn, O, O, Mn

B. The answers give coefficients of 1, but these should not be written in the answers:

