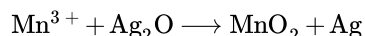


1.8: Balancing Redox Reactions

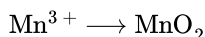
In any reaction, it is useful to quantify things. How much product will there be? How much of each reactant do we need to add? What ratios do we need? There are an awful lot of reactions for which this process is straightforward, but sometimes it can be tricky. Redox reactions are sometimes on the tricky side (although certainly not always). For that reason, it's good to have a reliable method for balancing redox reactions: determining the ratios of reactants needed to give the products in the proper amounts.

Suppose, for example, we have a reaction in which silver oxide (Ag_2O) reacts with manganese ion (Mn^{3+}) to produce manganese dioxide and silver. That's:

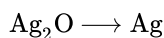


What would the balanced reaction look like?

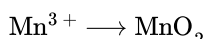
The first thing to do is make sure you are working with one **half-reaction** at a time. So that's:



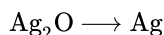
and



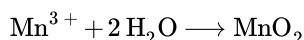
We start out by balancing the **atoms** involved, one at a time. First we look at the atoms other than hydrogen or oxygen, and we just balance those by adding the right coefficient.



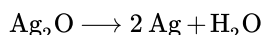
and



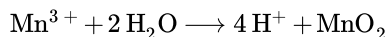
Second, we balance the **oxygen** atoms by adding water to one side or the other.



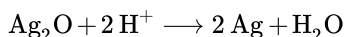
and



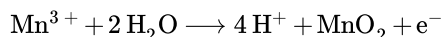
Third, we balance any **hydrogens** by adding protons.



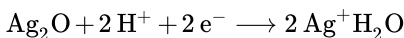
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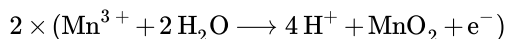
Fourth, we balance the **charge** by adding electrons.



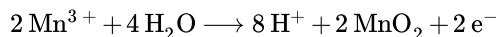
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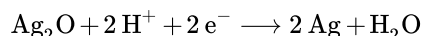
Fifth, we **multiply** so that the number of electrons is the same in both reactions.



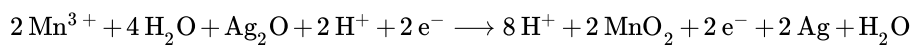
or



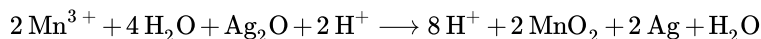
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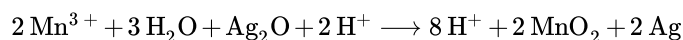
Sixth, we simply **add** these two reactions together. The reaction arrow functions like an equals sign. The left side adds to the left side, and the right side adds to the right.



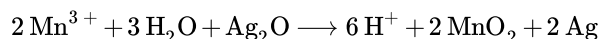
At that point, gratifyingly, the equation simplifies. Notice that we have added the same number of electrons to each side; they cancel out. That's perfect, because it means we have supplied just the right number of electrons from one half reaction to satisfy the other half reaction.



Also if we subtract one water from each side, things get slightly simpler.



Subtracting two protons from each side makes it simpler still.



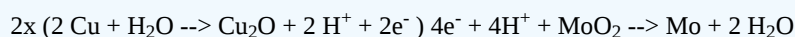
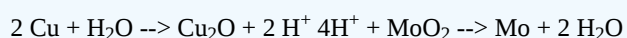
This method works for any redox reaction, no matter how complicated.

? Exercise 1.8.1

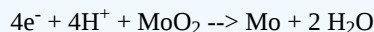
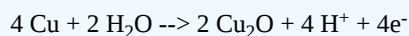
Balance the following reactions.

- $\text{Cu} + \text{MoO}_2 \longrightarrow \text{Cu}_2\text{O} + \text{Mo}$
- $\text{NH}_2\text{OH} + \text{Ag}_2\text{O} \longrightarrow \text{N}_2 + \text{Ag}$
- $\text{Fe}_3\text{O}_4 + \text{CO} \longrightarrow \text{Fe} + \text{CO}_2$
- $\text{I}_2 + \text{MnO}_4^- \longrightarrow \text{IO}_3^- + \text{MnO}_2$
- $\text{H}_3\text{Mo}_7\text{O}_{24} + \text{S}_2\text{O}_3^{2-} \longrightarrow \text{Mo} + \text{So}_3^{2-}$

Answer a



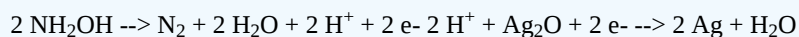
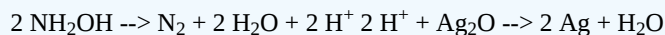
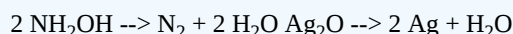
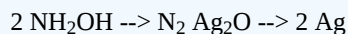
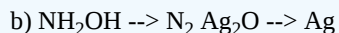
adding:



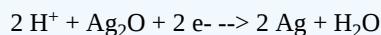
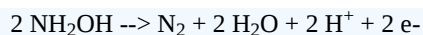
equals



Answer b



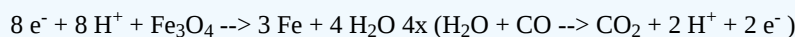
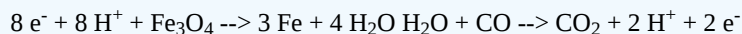
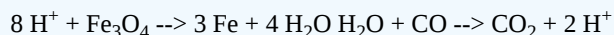
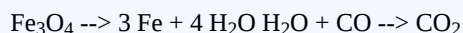
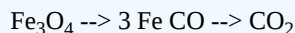
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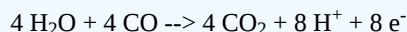
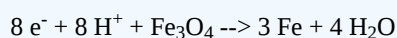
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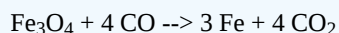
Answer c



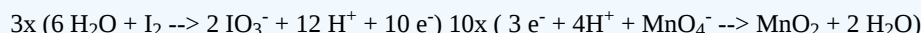
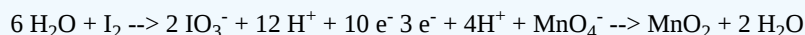
adding:



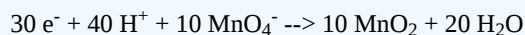
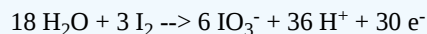
equals



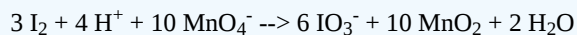
Answer d



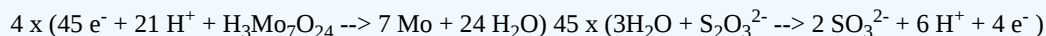
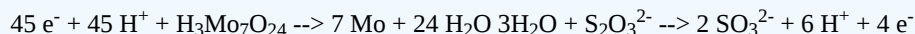
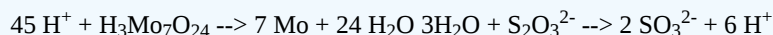
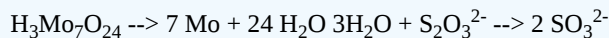
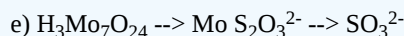
adding



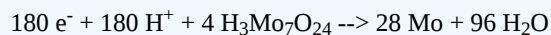
equals



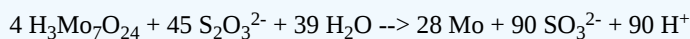
Answer e



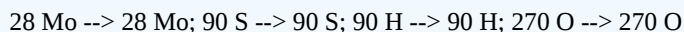
adding:



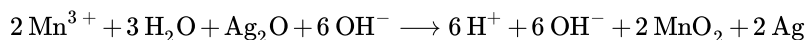
equals



checking:



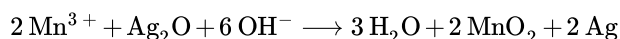
In the event that the reaction is described as occurring under basic conditions, we can simply "neutralize" our protons at the end, by adding hydroxide to both sides.



Which of course means

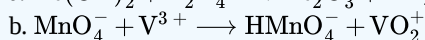
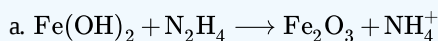


Simplifying to

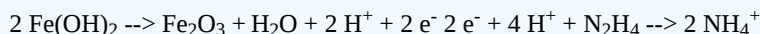
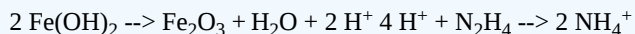
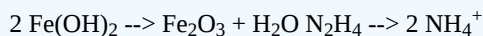
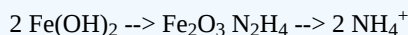
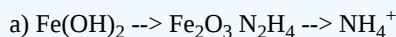


? Exercise 1.8.2

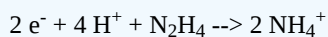
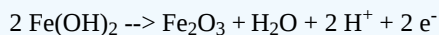
Balance the following reactions under basic conditions.



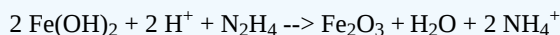
Answer a



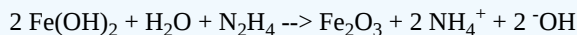
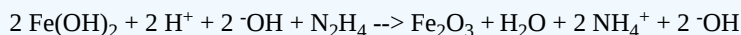
adding:



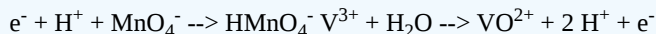
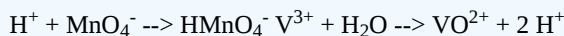
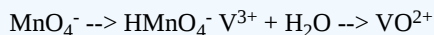
equals:



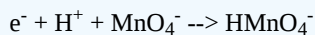
in basic conditions:

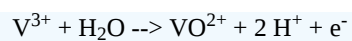


Answer b

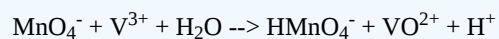


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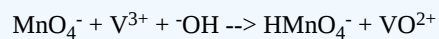
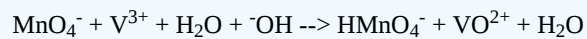
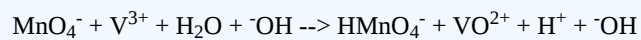




equals:



under basic conditions:



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