

ChemQuest 81

Oxidation and Reduction

Name: _____

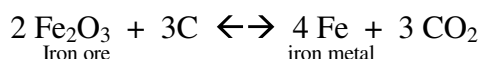
Date: _____

Hour: _____

Information: Oxygen and Oxidation

You have probably heard of antioxidants, which are substances (often vitamins) taken to prevent the oxidation of cells. When iron rusts we say that the iron has oxidized. What is oxidation?

Let's look at the chemical reaction for separating iron from iron ore:



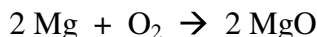
Critical Thinking Questions

- In Equation 1 above carbon is "oxidized" and iron ore is "reduced." Define each of the terms using the concept of gaining or losing oxygen.

Oxidizing: **substance becomes bonded to oxygen (or to more oxygen than it had)**

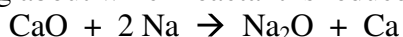
Reducing: **substance loses oxygen or becomes bonded to less oxygen than it had.**

- In the following reaction, is magnesium oxidized or reduced? Explain.



Oxidized, because magnesium gets bonded to oxygen.

- Which substance is reduced in the following reaction? (Note: When answering a question like this we are always talking about which reactant is reduced, not which product.)

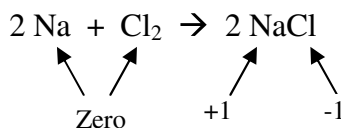


Calcium gets reduced because it loses oxygen.

Information: Oxidation States

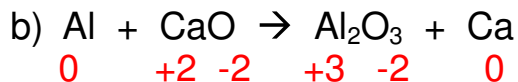
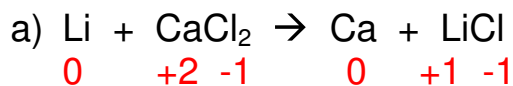
The term "oxidation state" is a fancy term for "charge." The charge, or oxidation state, of any atom by itself or in its natural state is zero. Here are some examples of substances that have an oxidation state of zero: Mg, Na, Cl₂, S, O₂, or any substance by itself or any normally diatomic substance.

When a substance is bonded we can often find its oxidation state from the periodic table:



Critical Thinking Questions

4. Assign oxidation numbers to each atom in the following chemical reactions:

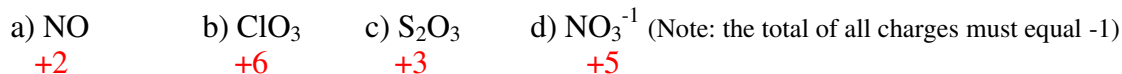


5. Sometimes it is difficult to determine from the periodic table. For example, Consider SO₂.

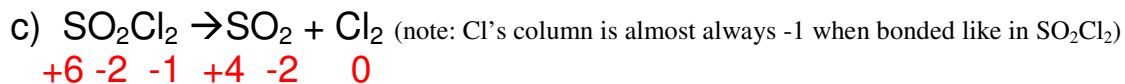
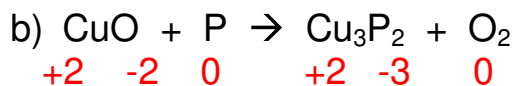
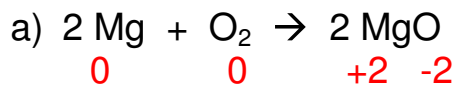
a) Both sulfur and oxygen are in the same column of the periodic table and we could predict the same oxidation state (or charge) of -2 for each of them when they are bonded ionically. what number? (include + or -)

b) What about in SO₂? They both can't have the exact same oxidation state. Here's a rule: *Oxygen almost always has a -2 oxidation state when it is bonded.* You'll have to figure out the S, by first assuming oxygen is -2. Treat S like an unknown "x": XO₂. Verify that the oxidation state for S is +4 in SO₂.

6. Find the oxidation state for each atom bonded to oxygen below:



7. Assign oxidation states to each atom in the following reactions:



8. A positive ion is formed when an atom loses electrons. gains OR loses?

9. A negative ion is formed an atom gains electrons. gains OR loses?

10. Consider again the isolation of iron from iron ore: $2 \text{Fe}_2\text{O}_3 + 3 \text{C} \leftrightarrow 4 \text{Fe} + 3 \text{CO}_2$.

- a) Which substance—iron or carbon—has an oxidation number that decreases during the reaction?
iron
- b) Which substance—iron or carbon—has an oxidation number that increases during the reaction?
carbon
- c) For a substance to become more positive it must lose gain OR lose electrons.
- d) For a substance to become more negative it must gain gain OR lose electrons.

Information: Electrons and Oxidation/Reduction

As you found out in question 10a, iron has its oxidation number decreased during the reaction in question 10. Its oxidation number gets *reduced* from +3 to 0.

Likewise, carbon's oxidation number gets increased from 0 to +4.

Earlier we defined oxidation and reduction in terms of gaining or losing oxygen. Now, let's formulate a definition for oxidation and reduction in terms of gaining or losing electrons.

Critical Thinking Questions

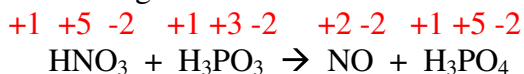
11. Define oxidation and reduction in terms of gaining or losing electrons:

Oxidation: **losing electrons to become more positive**

Reduction: **gaining electrons to become more negative**

12. In question 7c, chlorine oxygen, sulfur, OR chlorine was oxidized and sulfur oxygen, sulfur, OR chlorine was reduced.

13. Consider the following reaction:



- a) Assign oxidation numbers to every atom. (A hint: just like oxygen is always -2 when bonded, so also hydrogen is +1 when bonded.)
- b) Which atom is oxidized? **phosphorus**
- c) Which atom is reduced? **nitrogen**

ChemQuest 82

Half Reactions

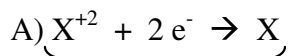
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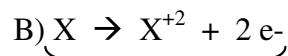
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Introduction Questions

- During oxidation, the oxidation number of a substance increases due to the loss of electrons.
increases OR decreases loss OR gain
- Let's assume that substance X gets oxidized. Which equation do you think is the best way to represent oxidation? [Note: "e⁻" stands for an electron.]



OR



Notice that the charge on X goes from +2 to 0

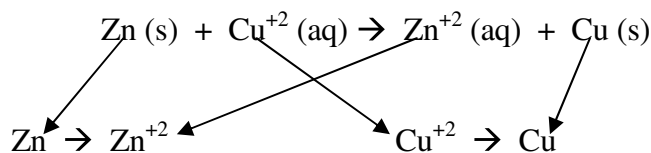
Notice that the charge on X goes from 0 to +2

- Let's assume that substance Y gets reduced. Which equation do you think is the best way to represent reduction?
 - $Y^{+3} + 3e^{-} \rightarrow Y$
 - $Y \rightarrow Y^{+3} + 3e^{-}$
- In the previous two questions, we saw that X⁺² had two electrons involved oxidation. Y⁺³ had three electrons involved in its reduction. Write the equation for the reduction of Z⁺¹.



Information: Half Reactions

A reaction in which substances undergo oxidation and reduction are called "redox reactions." Sometimes the reactions are written with ions in them. Here's a common redox reaction in which one substance is oxidized and the other is reduced:



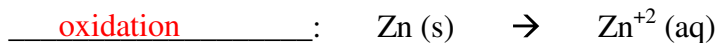
We can take all of the zinc substances to make a zinc "half reaction"

We can take all of the copper substances to make a copper "half reaction"

Critical Thinking Questions

5. The above half reactions need some electrons added to one of the sides so that they will look similar to questions 2 and 3.

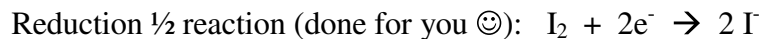
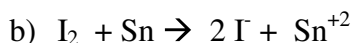
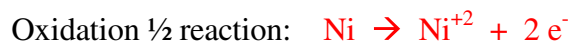
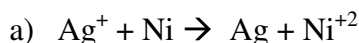
- a) Label each half reaction as “oxidation” or “reduction.” Also, follow the pattern of questions 2 and 3 and add electrons to the correct side of each equation.



- b) How many electrons did you add? Why did you choose this number?

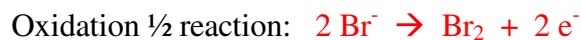
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6. Split the following reaction into two half reactions—an oxidation and a reduction half reaction. Write each half reaction with the proper number of electrons in each.



Question: Why are there 2 electrons instead of one?

Each iodine gains an electron.



7. True or False: A substance is reduced by gaining electrons. **TRUE**

Information: Reduction Potential

Potential: having the likelihood of occurring.

In electrochemistry there is a term, “reduction potential.” The reduction potential is a measure of how likely a substance is to be reduced. Reduction potential is measured in volts (V) and is given the symbol E^0 . The more positive the reduction potential (E^0), the more likely a substance is to be reduced.