# Characterizing Oxidation & Reduction Reactions

## Oxidation

- Originally, oxidation was defined as any chemical reaction where a compound or atom reacted with oxygen
- However, this definition was too simplified because there were very similar reactions that didn't contain oxygen
- Therefore, a more modern/theoretical definition of oxidation was introduced.
  - **Oxidation** is the *loss* of electrons

## Reduction

- Historically, refining metals consisted of taking an iron oxide ($Fe_3O_4$ or $Fe_2O_3$) out of the ground and "*reducing*" it down into pure iron atoms.
  - This process of iron refining consisted of converting iron cations into iron atoms by gaining electrons.
- Therefore, **reduction** today is defined as a *gain* of electrons
- This makes sense that if oxidation is the loss of electrons, then another atom, ion, or molecule must gain electrons because electrons cannot naturally exist on their own

## Redox Reactions

- If one atom/ion/molecule is oxidized in a reaction, another atom/ion/molecule must reduced
  - Electrons are simply being transferred from one chemical to another
  - This is called **reduction-oxidation reactions**, or just simply **redox reactions**
- Consider the reaction between aqueous copper(II) sulphate and zinc metal

$$Zn_{(s)} + CuSO_{4(aq)} \longrightarrow Cu_{(s)} + ZnSO_{4(aq)}$$

* aqueous means dissolved in water. To find what compounds are soluble, refer to page 6 of data book!

  - This can be written as an **ionic equation,** by simply writing the ions (cations and anions) separately for any compound that has the phase of an *aqueous solution* (aq).

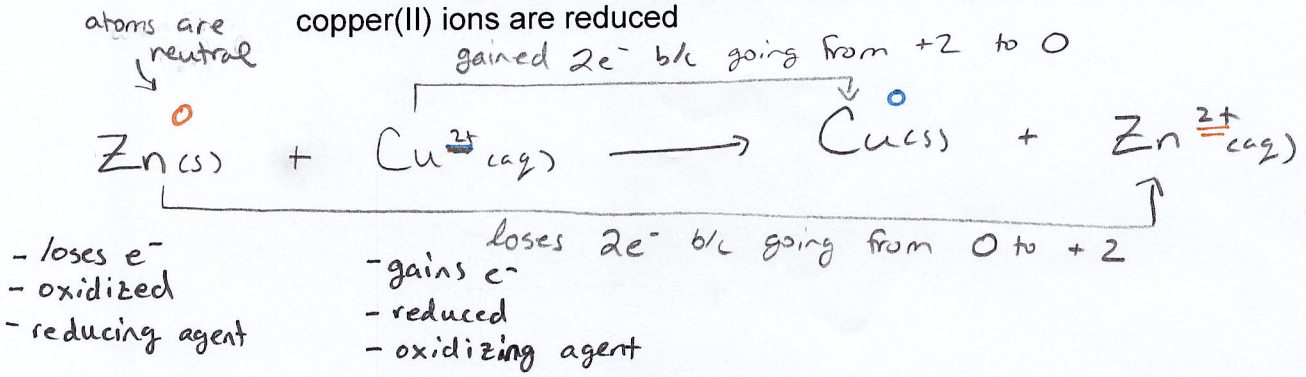
$$Zn_{(s)} + Cu^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \longrightarrow Cu_{(s)} + Zn^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$$

  - The sulphate ions are **spectator ions**, meaning they are not involved in the redox reaction (ie. not gaining or losing electrons) and can be omitted from the *ionic equation*. This leaves you with the **net ionic equation**

$$Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$$

* important to know difference b/w ionic vs. net ionic equations!

- This is an example of a redox reaction because the electron transfer can be observed
  - Zinc loses electrons to become positively charged, therefore zinc is oxidized
  - Copper ions gain electrons to become a neutral atom, therefore copper(II) ions are reduced




  - Since electrons are transferred from the zinc atom to the copper(II) ions, the copper(II) ions are responsible for the oxidation of zinc. A reactant that oxidizes another is called an **<u>oxidizing agent</u>**.
    - The *<u>oxidizing agent</u>* is therefore *<u>reduced</u>* because it gains electrons so that the other chemical can lose electrons
  - The zinc atom is responsible for the reduction of copper(II) ions. Since zinc reduces copper(II) ions, zinc is considered to be a reducing agent. A reactant that reduces another is called a **<u>reducing agent</u>**.
    - The *<u>reducing agent</u>* is therefore *<u>oxidized</u>* because it loses electrons so that the other chemical can gain electrons

✳ • Reducing and oxidizing agents will also be a reactant! You will never have a reducing or oxidizing agent that is a product of a reaction.

✳ • *<u>In general, metals tend to lose their electrons to form positive ions and most non-metals tend to gain electrons to form negative ions. Atoms are neutral</u>*

• LEOGER – Leo the lion goes Grrrrrr!

Lose Electrons = Oxidation

LEO

Gain Electrons = Reduction

GER

*****Now try pg. 437 #1-4 & pg. 440 #1, 2, 4, 7*****

# Answers to Textbook Questions

**Page 437**

1. During oxidation, a given substance loses electrons. Traditionally this loss was attributed to the presence of oxygen, or compounds containing oxygen. However, any substance that has the ability to gain electrons can cause oxidation to occur.

2. The original definition of reduction came from the reduction in mass of a metallic ore (such as iron ore) as it was transformed into a pure metal. The theoretical definition of reduction involves a substance gaining electrons. The key difference is the focus on a theoretical change in electron distribution as opposed to an observed change in mass. However, the breakdown of the metal oxide is described by both definitions.

3. The oxidizing agent is the $Fe^{2+}_{(aq)}$ ion, while the reducing agent is the Al(s).

4. A comparison of ionic charges among the reactants and products reveals that there has been no change in the distribution of electrons, meaning no redox reaction has taken place. Typically, in double replacement reactions, where all substances remain in the same ionic form, a redox reaction does not occur.

**Page 440**

1. In an oxidation reaction, a chemical will loss electrons. Electrons naturally do not exist on their own; therefore, some other chemical must gain those electrons. When a chemical gains electrons, this is known as reduction. Thus, oxidation and reduction reaction always occur in pairs to make sure that if electrons are lost, they are also being gained by another chemical.

2. In a redox reaction, a molecule/atom/ion gains electrons, while another molecule/atom/ion loses electrons. Oxidation means losing electrons. For one chemical species to be oxidized, the other chemical species must accept electrons. Therefore, the chemical species that accepts electrons, facilitating oxidation, is the oxidizing agent.

4. A formation reaction is any reaction in which all reactants are elements and combine to form a single, compound product. Knowing that lithium is a metal (also a very reactive metal), all metals have a tendency to lose electrons in a chemical reaction. Therefore, if lithium reacts with another element it will be oxidized and thus act as a reducing agent.

7.

   a) $Na_{(l)} + K^+_{(l)} \longrightarrow K_{(l)} + Na^+_{(l)}$
   b) The potassium ions are the oxidizing agents. Sodium is the reducing agent.