Course Learning Outcomes for Unit V

Upon completion of this unit, students should be able to:

5. Identify the hazard classes as outlined by the Department of Transportation (DOT) and the basic DOT hazardous material regulations related to the identification, classification, labeling, marking, transporting, and response to hazardous material incidents.
   5.1 Identify the hazard class, descriptions, labels, markings, and placards that DOT requires when transporting oxidizers.
   5.2 Identify the response actions that are applicable to incidents involving oxidizers.

6. Describe key chemical specific factors or properties that should be considered when managing or responding to incidents involving corrosive materials (acids and bases), water reactive substances, pyrophoric materials, toxic substances, oxidizers, organic compounds, and polymeric materials.
   6.1 Identify the chemical properties, uses, and ill effects associated with common oxidizers as related to the tasks and safety of an EHS & FS professional.
   6.2 Identify workplace exposure concentrations associated with common oxidizers.

Reading Assignment

Chapter 5:
Principles of Chemical Reactions

Chapter 11:
Chemistry of Some Oxidizers

Unit Lesson

For Unit V, we will study the chemistry of some oxidizers as discussed in Chapter 11 of our textbook. Most or all of you have heard of oxidizers or even oxidation-reduction reactions (redox in short). These reactions, when controlled, can benefit our society. Examples are combustion of fuels, disinfection of water, household cleaning, and bleaching of fabrics. However, when the reactions get uncontrolled, fire and/or an explosion could result that may result in loss of life and property.

Before we get into these reactions, we will first review what an oxidizer is. According to Meyer (2014), the Department of Transportation (DOT) defines an oxidizer as a substance that may enhance or support combustion of other materials, generally by yielding its oxygen. However, an oxidizer does not necessarily have oxygen to give up. A substance that removes electrons from other substances is also an oxidizer (also known as an oxidizing agent). So, an “oxidizer may be elements, acids, or salts classified into families with hazards associated with each family” (Burke, 2003, p. 246). The elements include oxygen, chlorine, fluorine, bromine, and iodine. If you recall from the periodic table in Unit I, these elements belong to the same family.

To learn oxidation-reduction reactions, we have to know what an oxidation number or oxidation state is. This is defined as the ability of an ion or atom to combine with another ion or atom (Meyer, 2014, p. 423). It provides a way to keep track of electrons in redox reactions. In practice, there are rules for assigning oxidation numbers.

In Section 5.4 of our textbook, oxidation-reduction is also discussed in more detail. Basically, in an oxidation process, there is an increase in oxidation number and loss of electrons. In reduction, there is a decrease in oxidation number and gain of electrons.
In redox reactions, the equation should be written as the following:

- oxidizing agent + reducing agent → products.

A good example of a redox reaction between iron chloride and tin chloride is shown on pages 424-425 of the textbook.

The National Fire Protection Agency (NFPA) lists oxidizers in four classes (Classes 1 to 4), with Class 1 having the lowest activity. Class 4 has the highest activity where the materials may undergo explosive reactions when catalyzed or exposed to heat, shock, or friction.

**Common Oxidizers:** Many household products used to sanitize indoor/outdoor surfaces and swimming pools contain oxidizers such as calcium or sodium hypochlorite. Hydrogen peroxide is used to help heal insect bites, burns, and scrapes, and is also used in hair color products.

Fireworks are entertaining, but inherently dangerous. Used in the production of all fireworks is a mixture of an oxidizing agent and a reducing agent. The oxidizing agent could be sodium chlorite/chlorate or perchlorate, and the reducing agent could be sulfur, pulverized magnesium, or aluminum flakes (Meyer, 2014).

There are only a few ammonium compounds that are thermally stable, so the use of them is limited. A common compound that is used commercially is ammonium nitrate, which is used as a fertilizer. Another example of an ammonium compound used is ammonium perchlorate, which accounts for, “70% of the solid propellants used by the aerospace industry to propel space shuttles” (Meyer, 2014, p. 445).

Notable incidents involving ammonium compounds include the following:

- 1947 SS Grandcamp incident in Texas City, Texas: The ship was carrying nearly 2280 tons of fertilizer grade ammonium nitrate when it caught fire. The heat generated by the fire resulted in the decomposition of the ammonium nitrate (Meyer, 2014). The decomposition products, oxygen and nitrogen dioxide, supported combustion in the storage hold of the ship, a confined space, resulting in an explosion.
- 1995 Oklahoma bombing of the Murrah Federal Building: Fertilizer grade ammonium nitrate and diesel fuel were mixed and detonated (Schultz, 1999). For additional information, visit http://www.newton.dep.anl.gov/askasci/chem99/chem99431.htm.

Other common oxidizers include the following:

- oxidizing chromium compounds (more commonly called hexavalent chromium with +6 oxidation state),
- sodium or potassium permanganate,
- metallic nitrite or nitrates,
- metallic peroxides and superoxides,
- potassium persulfate and sodium persulfate, and
- matches.

Oxidation–reduction reactions, also called redox reactions, greatly benefit our modern lifestyle. When oxidation–reduction reactions are conducted in a controlled fashion, the energy they release can be harnessed to our advantage. However, when redox reactions occur in an uncontrolled fashion, the generated energy is released into the immediate environment where it can initiate or intensify fire and explosion, resulting in the loss of life and property. This necessitates the study of redox reactions by EHS and FS professionals responding to hazardous materials incidents.

**References**


**Suggested Reading**

CrashCourse. (2013). Redox Reactions: Crash course chemistry #10 [Video file]. Retrieved from https://www.youtube.com/watch?v=lQ6FBA1HM3s