



Online Chemistry Course (OLCC)

Chemical Safety: Protecting Ourselves And Our Environment

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New Traditions in Laboratory Safety
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Workers in many hazardous fields (e.g., seamen and construction workers) have developed traditions of working together for mutual protection and the maintenance of correct professional standards. In the same way, laboratory workers have come to realize that the welfare and safety of each individual depends on clearly defined attitudes of teamwork and personal responsibility. Learning to participate in this culture of habitual risk assessment, experiment planning, and consideration of work-case possibilities for oneself and one's fellow workers is as much a part of a scientific education as learning the theoretical background of experiments or the step-by-step protocols for doing them in a professional and craftsmanlike manner.[1]

Welcome to the online course “Chemical Safety: Protecting Ourselves And Our Environment.” Our goal in this course is to provide information and ideas to help you make safety a fundamental part of laboratory work. One of our texts for this course, *Prudent Practices in the Laboratory*, was written as a guide for workers in laboratories to incorporate new information about the hazards of materials, improved ways of handling chemicals, and new governmental regulations. This guide is based on what a prudent person would do. “Prudent” is defined as “having good sense in dealing with practical matters and using good judgment to consider consequences and to act accordingly”. [2]

The outline for this course is designed around the activities involved in planning and executing an experiment in the laboratory. The course is organized around three central issues in designing and executing an experiment in the laboratory. Each section will be divided into three week-long components.

- I. How does a prudent person plan a laboratory experiment?
 - a. How are we exposed to chemicals?
 - b. How can we evaluate the hazards of the materials we work with?
 - c. How do I use equipment properly?
- II. How does a prudent person manage chemicals and dispose of wastes to minimize risk from exposure to hazardous materials?
 - a. How do I handle and manage the chemicals needed for my project?
 - b. How can I minimize generation of waste?
 - c. How do I handle the wastes generated in my project?
- III. How does a prudent person prevent or respond to an emergency in the laboratory?
 - a. How can I prevent accidents?
 - b. How do I respond to an emergency?
 - c. What rules and regulations cover my work in the laboratory?

A unique feature of this course is a weekly paper presentation by an expert in the topic under discussion. You will not only read their papers but will be able to carry out a discussion online. These activities are the virtual equivalent of attending seminars at a national meeting of chemists. Each week there will also be background readings from our texts *Prudent Practices* and the handbook *Safety in Academic Chemistry*.

Laboratories from the American Chemical Society. Through the discussion list you will interact with students from many different campuses to foster a sense of teamwork and to discuss ways of improving our safety habits. Safety and health involve evaluating hazards and assessing risks. Students will have a better understanding of what is involved in such decision making and the consequences of poor decisions.

Each week you will participate in meetings on campus with your instructor and fellow students. Class time will be spent discussing readings, web sites, and assignments. In addition you will be participating in online discussions with other students and authors of papers. Your instructor will make specific assignments and will be responsible for establishing the grading criteria for the course.

In the past safety was not always a priority. "Until recently, the chemical hazards in many laboratories were not accepted and taken into account by those working in them, and accordingly the necessity of putting 'safety first' was not fully appreciated.[1]" One of my Christmas presents this year was copy of "Asimov on Chemistry." One chapter in this book had the attention getting title "Death in the Laboratory." In this essay Asimov discusses the challenges and hazards of the discovery of the element fluorine. Discussing the Nobel Prize winning discovery of xenon fluoride he noted:

Just mix a little xenon and fluorine in a nickel container and astonish the world, and maybe win a Nobel Prize. But do you know what would have happened if the average chemist in the average laboratory had tried to mix a little xenon with a little fluorine? A bad case of poisoning, very likely, and, quite possibly death.

Carl Wilhelm Scheele (1774-1786) studied a number of acids including hydrogen fluoride, hydrogen sulfide, and hydrogen cyanide and reported the taste and odor of these highly toxic materials. Humphrey Davy (1778-1829) tried to isolate fluorine by electrolysis of calcium fluoride but failed and was severely poisoned as a result. Other chemists suffered in their quest for this element. Thomas and George Knox were severely poisoned and P. Louyet and Jerome Nickles died of fluorine poisoning. Fluorine was finally isolated in 1886 by Ferdinand Frederic Henri Moissan (1852-1907).

When I took my first college chemistry courses in the 1960's, benzene, mercury and other toxic materials were commonly used in undergraduate laboratories. Waste materials were poured down the drain. A few years later attitudes began to change and new procedures were implemented to protect workers in laboratories and protect the environment.

Improvements in the safe handling of hazardous materials come in several ways. One approach is to make the physical environment safer by providing safety equipment, ventilation, and other technology improvements. Safety also requires improving the knowledge and skills of laboratory workers and to make changes in their attitudes and behaviors which create a culture of laboratory safety. *Prudent Practices* notes that "the culture of laboratory safety depends ultimately on the working habits of individual

chemists and their sense of teamwork for protection of themselves, their neighbors, and the wider community and environment." Dr. David H. Beach , molecular biologist at Cold Spring Harbor Laboratory noted that "good laboratory practice, consideration for other people, and safety are three totally related issues."^[3]

Attitudes and behaviors are fundamental for creating a safe working environment. On February 1, 2003 the space shuttle Columbia disintegrated 16 minutes before it was due to land at Kennedy Space Center. A chunk of foam tore off the booster rocket shortly after liftoff and tore a hole through the shuttle's insulation. The heat of reentry destroyed the wing of the shuttle. An investigation of the accident resulted in recommendations to prevent a reoccurrence – eliminate launch debris, toughen the wing, and develop a plan for emergency repairs in space. The investigators noted that these recommendations for technical solutions will not help unless NASA "changes its culture" for decision making. Attitudes of superiority, fear of retribution by lower-level employees, communication problems, and strained relationships between key NASA divisions are all part of the culture that must be changed. This case highlights the importance of attitudes of safety that must be cultivated in the workplace whether it is a laboratory, industrial plant, or other project.

A culture of safety makes for better science. Dr. Phillip A. Sharp, Professor of Biology at MIT and winner of 1993 Nobel Prize for Physiology or Medicine, observed: [3]

Safety is planning and organizing and controlling what you are doing, not responding in a rush, not hastily doing something. Not thinking about what you are doing leads to unsafe things. And the best science, the best experiments, the best experimentalists are people who plan everything. They have complete control of their experiment. They know every reagent and how it works. They have it all organized before them. They have a protocol sheet they are going to do and they are going to follow that protocol sheet and they systematically work through. And when they put all that protocol and experimental design together, they incorporate the fundamental good rules of safety. That's the best experimentalists. If you can design your experiments that way you will be safe.

As scientists explore new areas such as biotechnology and materials science, a culture of safety will guide their efforts. At the 18th. Biennial Conference in Chemical Education this past summer, a symposium on nanotechnology highlighted classroom experiments in this exciting new area of research. It was noted that nanoscale materials have different physical properties than their bulk counterparts. Nanoparticles of gold can be red, orange, green, or purple depending on their size. Chemical and physical properties also are different at the nanoscale. What about the health hazards of these materials? Toxicologists are just beginning to explore the hazards of nanoparticles. In most cases the hazards are "unknown". By recognizing the possible hazards of working with very small particles that can be easily airborne and inhaled and absorbed into our bodies, we can apply good laboratory practice to reduce the risk of exposure to ourselves and protect the environment.

1. Council, N.R., *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*. 1995, Washington, D.C.: National Academy Press.
2. Corporation, M., *Encarta® World English Dictionary*. 2004, Bloomsbury Publishing Plc.
3. Safety, H.H.M.I.O.L., *Practicing Safe Science*. 1992.