Virtual ChemLab

General Chemistry Laboratories
(High School Version)

Installation and Overview
Overview of ChemLab and Workbook

Welcome to Virtual ChemLab, a set of realistic and sophisticated simulations covering general and organic chemistry laboratories. In these laboratories, students are put into a virtual environment where they are free to make the decisions that they would confront in an actual laboratory setting and, in turn, experience the consequences. These laboratories include simulations of inorganic qualitative analysis, quantum chemistry experiments, gas properties, titration experiments, calorimetry, organic synthesis, and organic qualitative analysis. This version of Virtual ChemLab is intended to be used in conjunction with this workbook, which contains thirty laboratory assignments covering the topics of stoichiometry, atomic theory, gas properties, thermodynamics, chemical properties, acid-base chemistry, and electrochemistry. Many of these “virtual” laboratory assignments can also be found as “real” assignments in the text or accompanying laboratory manual, but there are also a significant number of new assignments, such as Thompson’s cathode ray tube experiment or the Millikan oil drop experiment, that will provide previously unavailable opportunities to perform experiments. This overview and the installation instructions are for the high school, single user version of Virtual ChemLab: General Chemistry Laboratories. A brief description of the five general chemistry laboratories available in Virtual ChemLab is given below.

The general features of the inorganic simulation include twenty-six cations that can be added to test tubes in any combination, eleven reagents that can be added to the test tubes in any sequence and any number of times, necessary laboratory manipulations, a lab book for recording results and observations, and a stockroom for creating test tubes with known mixtures, generating practice unknowns, or retrieving instructor assigned unknowns. The simulation uses over twenty-five hundred actual pictures to show the results of reactions and over two hundred twenty videos to show the different flame tests. With twenty-six cations that can be combined in any order or combination and eleven reagents that can be added in any order, there are in excess of 10^{16} possible outcomes in the simulation.

The purpose of the quantum laboratory is to allow you and your fellow students to explore and better understand the foundational experiments that led to the development of quantum mechanics. Because of the very sophisticated nature of most of these experiments, the quantum laboratory is the most “virtual” of the Virtual ChemLab simulations. In general, the laboratory consists of an optics table where a source, sample, modifier, and detector combination can be placed to perform different experiments. These devices are located in the stockroom and can be taken out of the stockroom and placed in various locations on the optics table. The emphasis here is to teach you to probe a sample (e.g., a gas, metal foil, two-slit screen, and so forth) with a source (e.g., a laser, electron gun, alpha-particle source, and so forth) and detect the outcome with a specific detector (e.g., a phosphor screen, spectrometer, and so forth). Heat, electric fields, or magnetic fields can also be applied to modify an aspect of the experiment. As in all Virtual ChemLab laboratories, the focus is to give you the ability to explore and discover, in a safe and level-appropriate setting, the concepts that are important in the various areas of chemistry.

The gas experiments included in the Virtual ChemLab simulated laboratory allow you to explore and better understand the behavior of ideal gases, real gases, and van der Waals gases (a model real gas). The gases laboratory contains four experiments each of which includes the four variables used to describe a gas: pressure ($P$), temperature ($T$), volume ($V$), and the number of moles ($n$). The four experiments differ by allowing one of these variables to be the dependent variable while the others are independent. The four experiments include (1) $V$ as a function of $P$, $T$, and $n$ using a balloon to reflect the volume changes; (2) $P$ as a function of $V$, $T$, and $n$ using a motor driven piston; (3) $T$ as a function of $P$, $V$, and $n$ again using a motor driven piston; and (4) $V$ as a function of $P$, $T$, and $n$ but this time using a frictionless, massless piston to reflect volume changes and by using weights to apply pressure. The gases that can be used in these experiments include an ideal gas; a van der Waals gas whose parameters can be changed to represent any real gas; real gases including N$_2$, CO$_2$, CH$_4$, H$_2$O, NH$_3$, and He; and eight ideal gases with different molecular weights that can be added to the experiments to form gas mixtures.

The virtual titration laboratory allows you to perform precise, quantitative titrations involving acid-base and electrochemical reactions. The available laboratory equipment consists of a 50 mL buret; 5, 10, and 25 mL pipets; graduated cylinders; beakers; a stir plate; a set of eight acid-base indicators; a pH meter/voltmeter; a conductivity meter; and an analytical balance for weighing out solids. Acid-base titrations can be performed on any combination of mono-, di-, and triprotic acids and mono-, di-, and tri-basic bases. The pH of these titrations can be monitored using a pH meter, an indicator, and a conductivity meter as a function of volume, and this data can be saved to an electronic lab book for later analysis. A smaller set of potentiometric titrations can also be performed. Systematic and random errors in the mass and volume measurements have been included in the simulation by introducing buoyancy errors in the mass weighings, volumetric errors in the glassware, and characteristic systematic and random errors in the pH/voltmeter and conductivity meter output. These errors can be ignored, which will produce results
and errors typically found in high school or freshman-level laboratory work, or the buoyancy and volumetric errors can be measured and included in the calculations to produce results better than 0.1 percent in accuracy and reproducibility.

The calorimetry laboratory provides you with three different calorimeters that allow them to measure various thermodynamic processes including heats of combustion, heats of solution, heats of reaction, heat capacity, and heat of fusion of ice. The calorimeters provided in the simulations are a classic “coffee cup” calorimeter, a dewar flask (a better version of a coffee cup), and a bomb calorimeter. The calorimetric method used in each calorimeter is based on measuring the temperature change associated with the different thermodynamic processes. You can choose from a wide selection of organic materials to measure the heats of combustion; salts to measure the heats of solution; acids, bases, oxidants, and reductants to measure the heats of reaction; metals and alloys to measure the heat capacity measurements; and ice to measure the melting process. Temperature versus time data can be graphed during the measurements and saved to the electronic lab book for later analysis. Systematic and random errors in the mass and volume measurements have been included in the simulation by introducing buoyancy errors in the mass weighings, volumetric errors in the glassware, and characteristic systematic and random errors in the thermometer measurements.

After installing the Virtual ChemLab simulations, the software is initially configured to run in a stand-alone or student mode where the laboratories are accessed either through the electronic workbook or by clicking on the General Chemistry door. The electronic workbook is new for the high school version and is designed to be used in conjunction with the student worksheets provided with the software. In this high school version, the entire simulation package is available for exploring and performing worksheet assignments, but electronic assignments cannot be received from the instructor nor submitted by you. However, if the Web Connectivity Option has been enabled, electronic assignments and your results can be exchanged via a standard internet connection. Details on setting up and using the Web connectivity feature is given in the various laboratory user guides. It is strongly suggested that the user guides be reviewed before running the software. Most questions and problems can be avoided if the user guides are studied carefully.

### System Requirements

#### Minimum system requirements are as follows:

**PC**

- Pentium 500 MHz (Pentium II or better recommended)
- 128 Mb RAM (256+ Mb recommended)
- CD-ROM drive (for installation only)
- 600 Mb of free disk space
- Display capable of and set to millions of colors (24 bit color)
- Minimum resolution 800 x 600 (1024 x 768 or higher strongly recommended)
- Windows 98 or Windows NT 4.0 or Windows 2000 Professional/ME or Windows XP
- QuickTime 5.0 or higher

**Macintosh**

- PowerPC (G3 or better recommended)
- 128 Mb RAM (256+ Mb recommended)
- CD-ROM drive (for installation only)
- 600 Mb of free disk space
- Display capable of and set to millions of colors (24-bit color)
- Recommended minimum resolution 832 x 624 (1024 x 768 or higher strongly recommended)
- OSX (any version)
- QuickTime 5.0 or higher

**Note:** The above requirements are the recommended minimum hardware and system software requirements for reasonable execution speeds and reliability. However, it should be noted that the software has been successfully installed and used on computers with significantly lower capabilities than the recommendations given above with corresponding reductions in execution speed and media access time.
**Installing Virtual ChemLab**

Locate and run the program “Setup ChemLab” (which is located in the appropriate operating system folder) on the CD-ROM drive and then follow the prompts. There is only one install option available for the student version, which installs the complete software package to the hard drive. The CD is not needed to run the program.

**Important Installation Notes and Issues**

1. The graphics used in the simulations require the monitor to be set to 24-bit true color (millions of colors). Lower color resolutions can be used, but the graphics will not be as sharp.

2. In the directory where Virtual ChemLab is installed, the user must always have read/write/erase privileges to that directory and all directories underneath. This condition is initially set by the installer, but this may have to be reset manually if the system crashes hard while running Virtual ChemLab. This is generally only a problem with the OSX operating system if multiple users login to the same OSX machine. This can also be a problem with advanced Windows operating systems if the user is not a Power User or higher.

3. When multiple users access the same installed software on a given computer, file ownership and read/write privileges become serious issues since Virtual ChemLab shares some files, to a certain degree depending on the installation, among users. (a) In a direct access installation or when multiple users on a network drive share the database, all users must have complete read/write/erase privileges to the directory (and all directories underneath) where the database is stored. (b) In a Web connectivity installation, either (i) the same computer login must be used for all ChemLab users (so file ownership is the same for all database files) or (ii) each user who creates a local ChemLab account (or new ChemLab user) must use the same computer login as when the account was created in order to maintain file ownership consistency. This will only be a problem with OSX machines and Windows operating systems using Restricted Users.

4. When using Virtual ChemLab under the Windows 2000 Professional or higher operating systems, users must be, at a minimum, a Power User in order for the program to have sufficient rights to run properly. The program will run as a Restricted User but the fonts will be incorrect along with other minor annoyances. In a server environment where a Restricted User is necessary, we suggest that a separate ChemLab account be setup, which gives the user Power User Status but only gives the user access to the ChemLab software. This is a Macromedia Director limitation.

5. Occasionally on all Windows platforms, the Virtual ChemLab installer will fail to load and execute. This can be corrected by going to www.javasoft.com downloading and then installing the most recent version of the java runtime software. The Virtual ChemLab installation software is a java based application.

6. QuickTime 5.0 or later is required for the software to run properly. The most recent version of QuickTime can be obtained at http://www.apple.com/quicktime/.

7. When the simulation software has been installed on a Windows 2000 Professional operating system, there is better performance and better system stability when the Windows 2000 Support Pack 2 has been installed.

8. For unknown reasons, on some machines the QuickTime videos will not play properly if the system QuickTime settings are in their default state. This can be corrected by changing the Video Settings in QuickTime to Normal Mode.

9. Printing in Virtual ChemLab does not work inside the OSX operating system.

10. There are occasional spontaneous shutdowns of the software in OSX. There are no known causes for this, but it appears to be a Macromedia Director issue.

**Getting Started**

Virtual ChemLab is launched by clicking on the VCL icon located on the desktop or in the Start Menu for you will be brought to a hallway containing three doors and a workbook sitting on a table (see Figure 1). Clicking on the electronic workbook opens and zooms into the workbook pages (see Figure 2) where you can select preset assignments that correspond to the assignments in the actual workbook. The Previous and Next buttons are used to page through the set of assignments, and the different assignments
can also be accessed by clicking on the section titles located on the left page of the workbook. Clicking on the Enter Laboratory button will allow you to enter the general chemistry laboratory (see below), and the Exit button is used to leave Virtual ChemLab.

From the hallway, you can also enter the general chemistry laboratory by clicking on the General Chemistry door. Once in the laboratory (shown in Figure 3), you will find five different laboratory benches that represent the five different general chemistry laboratories. Mousing over each of these laboratory benches pops up the name of the selected laboratory. To access a specific laboratory, click on the appropriate laboratory bench. While in the general chemistry laboratory, the full functionality of the simulation is available, and you are free to explore and perform experiments as dictated by their instructors or by their own curiosity. The Exit signs in the general chemistry laboratory are used to return to the hallway.

Detailed instructions on how to use each of the five laboratory simulations can be found in the user guides located in the Virtual ChemLab installation directory. These same user guides can also be accessed inside each laboratory by clicking on the Pull-Down TV and clicking on the Help button.