Introduction to the Chemistry Laboratory

Attention Student! Read the following carefully because your instructor may give you a quiz on this material.

Since your laboratory time is limited, it is important to come to each session prepared by at least one hour of detailed study of the scheduled experiment. This should be considered a standing homework assignment.

Each of the experiments are composed of four basic sections:

1. **Materials and Equipment-**-a list that includes the formulas of all substances used.
2. **Discussion**--a brief discussion of the principles underlying the experiment.
3. **Procedure**--detailed directions for performing the experiment with safety precautions clearly noted and disposal procedures for chemical waste provided throughout and identified by a waste icon.
4. **Report for Experiment**--a form for recording data and observations, performing calculations, and answering questions.

Follow the directions in the procedure carefully, and consult your instructor if you have any questions. For convenience, the letters and subtitles in the report form have been set up to correspond with those in the procedure section of each experiment.

As you make your observations and obtain your data, record everything in your lab notebook. Try to use your time efficiently; when a reaction or process is occurring that takes considerable time and requires little watching, start working on other parts of the experiment, perform calculations, answer questions on the report form, or clean up your equipment.

Except when your instructor directs otherwise, you should do all the work individually. You may profit by discussing experimental results with your classmates, but in the final analysis you must rely on your own judgment in completing the report form.

The next few pages will explain the proper procedures for writing your lab notebook and handling data.

Required Materials & Responsibilities

1. **Personal Materials.** The student must provide certain materials to facilitate work in the laboratory. The following items are required.

- **a)** **Notebook.** Although the lab experiments provide pages for reporting results and observations, space is limited and the student will need to make additional entries and calculations. All notes, observations, data, and calculations should be kept for reference to aid in the preparation of the lab report.
- **b)** **Safety Goggles.** It is mandatory that goggles be worn at all times while in the laboratory. No student will be allowed to work without them. The correct type may be purchased in the student store.
- **c)** **Calculator.**
- **d)** The following item is recommended but not required: **Protective Clothing.** Many chemicals are corrosive and can do serious damage to clothing. A lab coat or an old shirt is adequate to prevent this damage.
- **e)** Print out the experiment prior to class time. It is your responsibility to find the experiment online and print it out BEFORE coming to class. You need only the directions/procedure during lab.

2. **Record Keeping** Before each experiment is done you will prepare your lab notebook with the following items.

- **a.** The date you plan to do the experiment.
- **b.** The purpose of the Experiment.
- **c.** A listing of the equipment and chemicals you will use.
- **d.** A brief description of the procedure, detailed enough so that someone else could understand the basics of the experiment.
- **e.** Room for observations (data sheet) and conclusions.

Sometimes your lab notebook can be prepared in table form, especially for analytical experiments. An example will be given in the section devoted to preparation for the Qualitative Analysis Experiments in this manual.

3. **Laboratory Reports** A report is required of each experiment and will be used to determine a grade for that experiment. The report should be written or typed on plain white paper in a neat form and presented on the date due. The instructor will decide if the provided REPORT SHEET will be used or whether a FORMAL REPORT needs to be written. Late reports are heavily penalized! Ask the instructor when the report is due.

Laboratory Notebook Guidelines

The following guidelines are provided to acquaint students with the expectations for maintaining a laboratory notebook. Most laboratory activities will include preparation of a pre-lab, gathering of experimental observations and data acquisition, and submission of a report form after completion of each lab. The carbon copy of the pre-lab is due at the beginning of each laboratory period.

The laboratory notebook is first and foremost a record of one's work in the lab. If that seems obvious, consider the fact that many students INSIST on recording experimental observations and data on their hands, scrap paper, etc. A good scientist learns to "work" in a notebook just as surely as he/she learns to work in the lab.

While an expert at lab note taking may produce a notebook that is a work of art, the ultimate aesthetic appeal of a notebook is far less important than its logical sequence and clarity as a record of investigation. "Wanting it to look neat" is therefore not an acceptable excuse for not entering all data and observations directly in the notebook. Please continue to develop the habit of recording ALL your observations. This cannot be emphasized enough!

The purpose of the pre-lab is to allow the student to become familiarized with the basic principles of the experiment along with the tasks that he/she will be expected to execute in order to gather the appropriate data. The pre-lab will ALWAYS be checked for completion (and graded) before the student enters the laboratory. The pre-lab should contain the following:

1. at the top of the first page of an experiment:
   the complete experiment title
   the date
   your name
   lab partner (if appropriate)

2. at the top of EACH succeeding page:
   your name
   the experiment title

3. the body of the pre-lab should contain:
   a. **Purpose** – Using complete sentences, briefly state the purpose or goal of the experiment. WHY ARE YOU DOING IT? WHAT ARE YOU TRYING TO FIGURE OUT? Make sure to use the active voice in this section and throughout your report. It is usually more precise and less wordy than the passive voice.

   b. **Procedure –** A brief paragraph explaining the basic techniques and steps you will perform while doing the lab. This section should explain how you intend to accomplish your task in the laboratory (i.e procedure plan). Give balanced chemical equations as needed along with a logical sequence of data processing. It should include topics like:
      - Materials and Equipment – This list should contain a compilation of all the necessary chemicals and equipment necessary to carry out the experiment.
      - Safety Information – Before beginning any experiment, it is important to note potential hazards, safety precautions, and any pertinent physical data necessary for the experiment.

   c. **Data and Calculations** –Data should be recorded in neatly prepared and NUMBERED tables (use a ruler). Numbering of the tables will facilitate discussion of results at the conclusion of the experiment. You will fill-in the data tables throughout the course of the experimentation during your assigned lab period.

   d. **Observations** – In general, record any pertinent observations. Non-numerical information may be written in simple comment form.

As a final note, consider the following three points:

1. Use black ball-point ink when writing

2. Do NOT decorate errors; a single line through an entry will suffice—you may decide later it was correct after all!

3. Be sure to record PRIMITIVE data—for example, initial and final buret readings, not the difference done in your head

Precision and Significant Figures

When a measured value is determined to the highest precision of the measuring instrument, the digits in the measurement are called **significant digits** or **significant figures.**

Suppose we are measuring two pieces of wire, using the metric scale on a ruler that is calibrated in tenths of centimeters. One end of the first wire is placed at exactly 0.0 cm and the other end falls somewhere between 6.3 cm and 6.4 cm. Since the distance between 6.3 and 6.4 is very small, it is difficult to determine the next digit exactly. One person might estimate the length of the wire as 6.34 cm and another as 6.33 cm. The estimated digit is never ignored because it tells us that the ruler can be read to the 0.01 place. This measurement therefore has three significant figures (two certain and one uncertain figure).

The second wire has a length which measures exactly 6 cm on the ruler. Reporting this length as 6 cm would be a mistake for it would imply that the 6 is an uncertain digit and others might record 5 or 7 as the measurement. Recording the measurement as 6.0 would also be incorrect because it implies that the 0 is uncertain and that someone else might estimate the length as 6.1 or 5.9. What we really mean is that, as closely as we can read it, the length is exactly 6cm. So, we must write the number in such a way that it tells how precisely we can read it. In this example we can estimate to 0.01 cm so the length should be reported as 6.00cm

General Rules about Significant figures. A chemist makes many measurements in the laboratory, using tools that are sometimes very simple and sometimes very complicated, depending on the "exactness" desired. No measurement is really *exact*. Every measurement is limited by some **uncertainty**, a plus-or-minus range that must be attached to the measured quantity if you are to be sure that the true value is stated by the measurement. This uncertainty arises from the measurement process or from the measuring instrument. By using an instrument capable of finer measurements we can reduce the uncertainty; but we can never eliminate it entirely. We will use **significant figures** to express uncertainty in a measured quantity, as well as any *derived quantity* that may result from calculations based on measured quantities.

Your textbook probably discusses significant figures in greater detail than we can here. You should read that material as part of your preparation for any experiment. The main ideas behind significant figures as they will be used in this laboratory manual are summarized as follows:

1. The concept of significant figures applies to *measured quantities* because of the uncertainty associated with every measurement. It does *not* apply to exact numbers, such as counting numbers or numbers that are exact by definition.
2. The number of significant figures in a measurement is the number of figures that are known accurately plus one that is doubtful. The doubtful digit in a number properly expressed in significant figures is the *last digit shown.*
3. Counting significant figures always begins with the first nonzero digit and ends with the last digit shown - the doubtful digit. Notice that there is *no reference to the decimal point* in this statement. The location of the decimal point is determined by the units in which a measurement is expressed. It has nothing to do with the measurement process, and therefore nothing to do with the number of significant figures in a quantity.
4. Tail-end zeros to the right of the decimal point are used to indicate that they are significant, in accordance with Number 2 above. Accordingly, a tail-end zero *must* be used to the right of the decimal if it is the doubtful digit.
5. Tail-end zeros to the left of the decimal in large numbers are necessary to show the magnitude of the number, but they may or may not be significant. Use exponential notation so any doubtful digit zero appears to the right of the decimal as the last digit shown, in accordance with Numbers 2 and 4 above.
6. Rounding off; If the first digit to be dropped is less than 5, leave the preceding digit unchanged; if the first digit to be dropped is 5 or more, increase the preceding digit by 1. (If your instructor prefers a different rule for rounding off, use it. Only the doubtful digit will be affected.)
7. Addition - subtraction rule: Round off the answer to the first column that has a doubtful digit.
8. Multiplication - division rule: Round off the answer to the *same number* of the significant figures as the *smallest* number of significant figures in any factor.