MiraCosta College
Introductory Chemistry Laboratory
Experiment 1

Controlling Variables: The Period of a Pendulum

EXPERIMENTAL TASK

To determine which variables directly affect the period of a pendulum by controlling variables in a series of experiments.

Objectives

After completing this experiment, the student will be able to:

1. Design and carry out a set of simple experiments to systematically control variables in order to study a system
2. Make accurate and precise measurements, and record those measurements using standard units and the rules of significant figures.

Additional Reading

- General, Organic and Biological Chemistry, by Timberlake, sections 1.1 – 1.4 & 1.6
- Laboratory Handbook for General Chemistry, 2nd ed., by Griswold, et al, pp. 15, 16, 77, 78

Background

The Scientific Method: The definition of ***science*** is that it is *the systematic study of the universe, or a part thereof*. That is, in order for an activity to be "science", it is not sufficient that the activity involve studying something; the study must have a systematic method to it in order for it to be science. Chemistry is a science because it is the systematic study of a part of the universe. Specifically, ***chemistry*** *is the science of matter and the changes it undergoes*.

While scientists are as individual as artists, and no two scientists follow exactly the same process in carrying out their research, the **scientific method** summarizes the approaches used by all scientists. The basic steps in the scientific method are:

1. Identify the **system** of interest, and the specific **phenomenon** to be studied.
2. Gather information about the system from the literature and from preliminary **observations** and **measurements.**
3. Formulate one or more **hypotheses**, or possible explanations of the problem.
4. Choose one hypothesis, and design and carry out an **experiment** to test this hypothesis. The experiment must be carefully designed so that it yields information that specifically tests this one hypothesis.
5. Analyze and interpret the **data** (bits of information) from the experiment—do the results of the experiment support the hypothesis or contradict it, or are the results inconclusive?
6. If necessary, design and carry out more experiments to either further test this one hypothesis or to test others, if the first was found to be incorrect or incomplete.

The **system** is the part of the universe currently being studied. It might as big as the entire universe or as small as the nucleus of a hydrogen atom. In chemistry, the system is often just the collection of substances involved in a particular chemical reaction. The **phenomenon** is the behavior of the system under a particular set of circumstances (the plural of phenomenon is *phenomena*).

In chemistry there are many phenomena in which one particular measurable characteristic of a system is affected by a complex set of variables all working together. For instance, the rate of a reaction—how fast one set of substances is converted into another—depends on the concentrations of one or more of the reacting substances, the temperature of the reaction mixture, the energy required to break the bonds already present in the reacting substances, etc., while other variables, such as the concentrations of the product substances, do not affect the rate of the reaction. It is often very difficult to sort out which factors affect the final quantity and which do not.

In order to make sure that the experiment being used gives specific, usable results concerning the hypothesis being tested, all of the variables that affect the phenomenon being studied must be taken into account. In an ideal case, the experiment will be designed to hold every variable except one constant; the variable that is changed during the experiment is the one whose affect is being tested. In practice is difficult or impossible to hold EVERY other variable

completely constant, but in most cases these other variables can be controlled so that the effects from them can be reduced to a point where they can be ignored.

Experiment Design

During this laboratory period the system you will be studying is a pendulum, which consists of a string hanging from one end fixed to a support with the other end attached to a weight that is allowed to swing freely. When the weight is pulled to one side and released, it swings back and forth continually for a long time. The phenomenon you will examine is the **period** of the pendulum, which is the time it takes for the weight to swing from one side to the other and back again. It will be up to each group to first observe the pendulum, then develop hypotheses concerning which variables will affect the period—that is, which variables will change the period when they themselves are changed—and then design experiments to test each hypothesis.

For example, one variable that most people identify as possibly affecting the period of the pendulum is the amount of weight at the end of the string. The hypothesis in this case would be, "changing the amount of weight at the end of the pendulum will change the period of the pendulum." The experiment design would involve measuring the period with one amount of weight, changing the weight without changing any other variables, then measuring the period with the new weight and comparing it to the period with the original weight. If the result is that the period changed when the weight was changed, the result then supports the hypothesis; if the result is that the period did not change, the result then contradicts the hypothesis.

Every measurement includes error, and every observation has room for some doubt, so it is important to reduce inaccuracy by repeating each experiment many times. In the case of the pendulum, the period should be measured many times each particular experiment, and these values should be averaged. The easiest way to do this is to let it go, measure the time it takes for the pendulum to complete 10 full cycles, and then stop it. Dividing this total time by 10 gives the average period for that experiment.

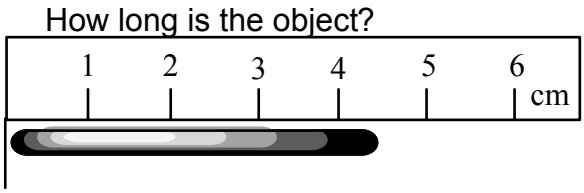
Measurements: One important aspect of nearly every experiment is making measurements. Be sure you understand how to use the meter stick, top-loading balance and stopwatch correctly so that no mistakes are made and experimental error is kept to a minimum. Follow the rules of significant figures in recording each measurement, and remember to include the correct unit with the measurement value.

The final result for this experiment will be the conclusion reached as to which variable(s) affect the period of the pendulum.

Pre-lab Questions

1. Imagine you are studying the growth rate of a particular type of tree, and that after initial observation you believe three variables may affect the rate of growth of this type of tree: number of hours of direct sunlight per day, amount of water per day, and the number of rocks in the soil around the tree. Write one hypothesis for each of the variables, and describe a set of experiments you would design to test these hypotheses.

2. Record this measurement to the appropriate number of significant figures.



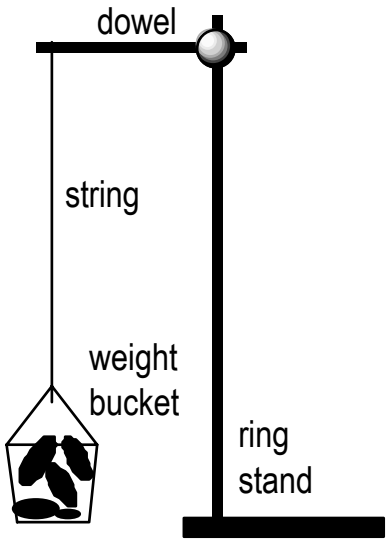
BEFORE STARTING THE EXPERIMENT

Safety

Always keep in mind the rules presented in both the "MCC Laboratory Safety Rules" and the Laboratory Handbook for General Chemistry. It is your responsibility to make sure that you follow all safety rules at all times, and to graciously help everybody else in the laboratory (including the instructor) to do the same.

EXPERIMENT PROCEDURE

The class will be divided into no more than 10 groups, which should give 2 or 3 students per group. Each group will use one pendulum apparatus that will already be assembled. This apparatus consists of a ring stand, a wooden dowel attached to the ring stand by means of a lamp, a string with one end attached to the end of the dowel and the other end attached to a small bucket, and gravel to be used to add weight to the bucket. The instructor will discuss the basic use of the pendulum, including how to change some of the variables, such as weight and length.



The group will first observe how the pendulum works, and discuss which 3 or 4 variables may have the most affect on the period. The group will then formulate one hypothesis for each variable, design a set of experiments where each hypothesis is tested by one experiment. Finally, the group will examine the results of each experiment to determine whether the results clearly support the hypothesis, clearly contradict the hypothesis, or are ambiguous. In the last case, the experiment should be repeated to see if the results can be improved.

Finally, each group must state their conclusions concerning each hypothesis—that is, for each variable tested, does that variable affect the period of the pendulum or not? It is the responsibility of each student to keep in her or his notebook a **clear** and **complete** record of the procedure, hypotheses, observations, measurements, discussion, conclusions, etc., throughout the laboratory period.

RESULTS

The data from each experiment should be presented in table form. Important observations should be included after the table.

DISCUSSION

State each hypothesis, briefly summarize the experiment performed to test it, and state the conclusion reached for that hypothesis. Finally, you must state which variable(s) affect the period of the pendulum.