

Experiments in General Chemistry I

CHM 11

Department of Physical Sciences
Kingsborough Community College
The City University of New York

Schedule of Laboratory Experiments

Each week we will meet to perform an experiment according to the schedule listed below. You are expected to bring your safety glasses and experimental procedure. The experimental background and procedure should be read before coming to the laboratory meeting. Students who do not arrive to the laboratory prepared will be asked to leave. Several of the experiments we will perform require the use of graphs in the data analysis (*). The graphing software we use is called Vernier Graphical Analysis. Bring a USB flash drive to these meetings.

Meeting	Experiment and Experiment Number
1	Check-in Density 1
2	The Empirical Formula of a Copper Oxide 3
3	The Preparation and Properties of Oxygen 4
4	The Determination of Acid Content in Vinegar 5
5	The Determination of Chloride Content in Seawater 6
6	The Determination of Hypochlorite in Bleach 7
7	Graphical Analysis* 2
8	Thermochemistry* 8
9	The Hydrogen Spectrum* 9
10	Spectrophotometry* 11
11	Chemical Bonding 10 Freezing-Point Depression* 12

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Experiments

(Refer to the course syllabus for the schedule of experiments)

- 1 **Density** (Reading assignment: Chang, Chemistry, 9th edition, pp. 14-19)
- 2 **Workshop in Graphing Experimental Data**
(This experiment will be performed in a computer laboratory. Ask your instructor for details.)
(Bring a transparent ruler and a USB flash drive)
- 3 **The Empirical Formula of a Copper Oxide**
(Reading assignment: Chang, Chemistry, 9th edition, pp. 86-92)
(Safety glasses required)
- 4 **The Preparation and Properties of Oxygen**
(Reading assignment: Chang, Chemistry, 9th edition, pp. 92-97)
(Safety glasses required)
- 5 **The Determination of Acid Content in Vinegar**
(Reading assignment: Chang, Chemistry, 9th edition, pp. 127-131, 142-148)
(Safety glasses required)
- 6 **Volumetric Determination of Chloride Content in Seawater**
(Reading assignment: Chang, Chemistry, 9th edition, pp. 122-127)
(Safety glasses required)
- 7 The Determination of Hypochlorite in Bleach
(Reading assignment: Chang, Chemistry, 9th edition, pp. 131-142)
(Safety glasses required)

- 8 **Thermochemistry**
(Reading assignment: Chang, Chemistry, 9th edition, pp. 239-245)
(Safety glasses required. Bring USB flash drive)
- 9 **The Hydrogen Spectrum**
(Reading assignment: Chang, Chemistry, 9th edition, pp. 274-279)
(Bring USB flash drive)
- 10 **Chemical Bonding**
(Reading assignment: Chang, Chemistry, 9th edition, pp. 400-408)
- 11 **Spectrophotometry**
(Reading assignment:.. http://en.wikipedia.org/wiki/Beer-Lambert_law)
(Safety glasses required. Bring USB flash drive)
- 12 **Freezing-Point Depression**
(Reading assignment: Chang, Chemistry, 9th edition, pp. 521-525)
(Safety glasses required. Bring USB flash drive)

Introduction

Welcome to the general chemistry laboratory. In this manual you will find procedures for the experiments we will perform throughout the semester in General Chemistry I. Below is a list of few items you will need for this laboratory. Purchase them as soon as possible. General Chemistry I experiments are almost always performed in Room S324, located on the third floor of the S building. **Experiment 2: Workshop in Graphing Experimental Data is an exception.** This experiment will be performed in one of the campus computer laboratories. The office for the Department of Physical Sciences is located in room S243, on the second floor of the S building.

- Scientific calculator: Graphical calculators are not necessary for this course. Scientific calculators are available in the bookstore as well as in office supply stores.
- Ruler with metric divisions and see-through.
- A USB flash drive: You will perform experiments in which you need to save data.
- Safety glasses or goggles: Sunglasses or regular prescription glasses are not acceptable. Acceptable safety glasses must offer side protection so that liquid splashes do not enter the eyes.

While not required, there are several items that may be helpful for you to have.

- A towel, sponge, and detergent
- Apron or lab coat
- Stapler

Laboratory Meetings

Read the schedule of experiments listed in the General Chemistry I syllabus. Knowing the schedule of experiments will help you to arrive prepared to each laboratory meeting. To arrive prepared to perform an experiment requires several actions on your part. Be sure to read the entire experiment description prior to coming to each laboratory meeting. For most experiment there are one or more sections in the textbook CHEMISTRY MATTER AND ITS CHANGES by Brady and Senese that you should also read before arriving to the meeting. These sections are listed in the Table of Contents. You may be quizzed to assess your understanding of the material prior to performing the experiment. You may also receive pre-lab questions that must be answered prior to performing the experiment.

Be sure that you bring your laboratory manual, a scientific calculator, and eye protection to each laboratory meeting. Failure to arrive on-time with each of these items is cause for the instructor to ask you to leave the laboratory. Arriving prepared for each experiment is your responsibility.

Laboratory Safety and Behavior

Safety is the most important subject in any science laboratory, teaching or research. Laboratory safety is taken very seriously by Kingsborough Community College and the Department of Physical Sciences. Failure to comply with any of the laboratory safety requirements is cause for expulsion from the laboratory. Common reasons for removal of a student from the laboratory include:

- Failure to wear proper eye protection at all times
- Wearing shoes that do not cover the entire foot
- Eating or drinking in the laboratory

- Showing up late and missing the pre-lab safety lecture
- Performing experiments not approved by the instructor
- Not bringing and reading the laboratory manual
- Failure to listen to instructions given by the instructor or the college laboratory technician (CLT)
- Horseplay

Laboratory Reports

Each experiment has an associated report that must be submitted for credit. Below are a few general guidelines to consider when preparing your reports:

- Include a coversheet that is properly completed
- Include all data sheets
- Include all calculations sheets
- Show all calculations on a separate piece of paper
- Include responses to questions on a separate piece of paper indicated in the experiment description
- Include any additional work as assigned by your instructor

All calculations must be shown in laboratory reports that you submit for credit. No credit for calculations will be given unless work is shown.

Take notes during the experiment. In science courses it is very important to write down all observations during an experiment. These observations may help you to explain what happened when you are writing your report.

Unless otherwise noted, reports are due one week after you perform the experiment. Calculations should be shown and easy to read for the instructor. Each report must have the title page (page IV) stapled to the front of the report and correctly completed. This includes names of any lab partners who performed the experiment with you. Make ten photocopies of page IV since each report will require a title page. In general, the report for an experiment is due one week after the experiment is performed. Your instructor will let you know if there are any changes to this policy for specific cases like holidays or snow days. If a report is not turned in at the beginning of the laboratory meeting one week after the experiment was performed it is considered late and may be subject to a late penalty or not accepted at all. Late reports may be accepted at the instructor's discretion. However, the decision to accept or not accept late reports is your instructor's choice. Below are a few details that might help you to develop your reports:

- Were observations written in the observations sheet?
- Were measurements (data) written in the data sheet?
- Were calculations performed correctly? Are there calculations errors?
- Where necessary, were calculations properly shown? Were problems worked out?
- Were questions answered with reasonable effort? On a separate sheet of paper if asked?
- Were graphs properly drawn?
- Were results from graphs used in (correctly) in the calculations?
- Was the cover sheet properly completed?
- Was the report turned in on time? Were specific instructions given in the laboratory followed?

Department of Physical Sciences Kingsborough Community College
The City University of New York

General Chemistry I

Laboratory Report

Name _____

Partner's Name (s) _____

Section _____

Date experiment was performed _____

Experiment Number _____

Title: _____

Make 10 copies of this sheet.

Constants and Conversions

Constants

Mass of a proton	1.672623×10^{-27} kg	
Mass of a neutron	$1.6749286 \times 10^{-27}$ kg	
Mass of an electron	$9.1093897 \times 10^{-31}$ kg	
Speed of light (c)	2.99792458×10^8 m/s	
Planck's constant (h)	6.626075×10^{-34} J·s	
Gas constant (R)	8.314510 J/K·mol	0.08206 L·atm/K·mol
Faraday's constant (F)	96,485 C/mol	
Avogadro's number (N_A)	6.0221367×10^{23} /mol	
Boltzmann constant	1.380658×10^{-23} J/K	
elementary charge	$1.60217733 \times 10^{-19}$ C	

Length

1 nanometer (nm)	10^{-9} m	
1 Angstrom (Å)	10^{-10} m	
1 micrometer (µm)	10^{-6} m	
1 millimeter (mm)	10^{-3} m	
1 centimeter (cm)	10^{-2} m	
1 decimeter (dm)	10^{-1} m	

Mass

1 gram (g)	0.03527 oz	
1 kilogram (kg)	2.2046 lbs	
1 metric ton	1×10^6 g	

Volume

1 liter (L)	1 dm ³	1000 mL	1.057 qt.
1 milliliter (mL)	1 cc	1 cm ³	0.001 L
1 cubic foot (ft ³)	28.32 L		

Pressure

1 atmosphere (atm)	760 torr (mm Hg)	1.01325×10^5 N/m ² (Pa)	14.7 lbs/in ²
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Energy

1 joule (J)	0.2389 calorie (cal)	
1 liter atmosphere (L·atm)	101.267 J	
1 kilocalorie (kCal)	1000 cal	
1 electron volt (eV)	1.602×10^{-19} J	

Temperature

$T_K = T_{°C} + 273.15$	
$T_{°F} = 1.8T_{°C} + 32$	

Solubilities of Salts in Water

- Most salts of the acetate ion ($\text{C}_2\text{H}_3\text{O}_2^-$), the nitrate ion (NO_3^-), the chlorate ion (ClO_3^-), and the perchlorate ion (ClO_4^-) are soluble.
- Most salts of the group I alkali metals (Li^+ , Na^+ , K^+ , Rb^+ , Cs^+) are soluble.
- Most salts of the ammonium ion (NH_4^+) are soluble.
- Most salts of the chloride (Cl^-), bromide (Br^-), and iodide (I^-) ions are soluble except those of Ag^+ , Pb^{+2} , Hg_2^{+2} , and Cu^+ .
- Most salts of the sulfate ion (SO_4^{2-}) are soluble except those of Ca^{+2} , Ba^{+2} , Sr^{+2} , Pb^{+2} , and Hg^{+2} .
- Most salts of the sulfide ion (S^{2-}) are insoluble except those of the alkali metal ions and the ammonium ion.
- Most salts of the hydroxide ion (OH^-) are insoluble except those of the alkali metal ions, the ammonium ion, Ba^{+2} ion, Sr^{+2} ion, and Ca^{+2} ion.

Concentrated Acids and Bases

Reagent	Molarity	Density (g/mL)
Acetic acid	17.4	1.05
Hydrochloric acid	11.6	1.18
Ammonium hydroxide	14.8	0.90
Nitric acid	16.0	1.42
Phosphoric acid	14.7	1.70
Sulfuric acid	18.0	1.84

Polyatomic Ions

Name	Formula	Name	Formula
ammonium	NH_4^+	thiosulfate	$\text{S}_2\text{O}_3^{2-}$
acetate	$\text{C}_2\text{H}_3\text{O}_2^-$	dithionate	$\text{S}_4\text{O}_6^{2-}$
carbonate	CO_3^{2-}	hypochlorite	ClO^-
hydrogen carbonate	HCO_3^-	chlorite	ClO_2^-
chromate	CrO_4^{2-}	chlorate	ClO_3^-
dichromate	$\text{Cr}_2\text{O}_7^{2-}$	perchlorate	ClO_4^-
nitrate	NO_3^-	peroxide	O_2^{2-}
nitrite	NO_2^-	permanganate	MnO_4^-
sulfate	SO_4^{2-}	hydroxide	OH^-
hydrogen sulfate	HSO_4^-	cyanide	CN^-
sulfite	SO_3^{2-}	oxalate	$\text{C}_2\text{O}_4^{2-}$
thiocyanate	NCS^-	phosphate	PO_4^{3-}
mercury(I)	Hg_2^{2+}	hydrogen phosphate	HPO_4^{2-}

Concentration Units

Name	Relationship	Units
molarity	$\frac{\text{moles of solute}}{\text{volume of solution}}$	$\text{mol} \cdot \text{L}^{-1}$
mass percent	$\frac{\text{mass of solute}}{\text{mass of solution}} \times 100$	%
mole fraction	$\frac{\text{moles of A}}{\text{moles of all components}}$	unitless
molality	$\frac{\text{moles of solute}}{\text{mass of solvent}}$	$\text{mol} \cdot \text{kg}^{-1}$
parts per million	$\frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6$	ppm
normality	$\frac{\text{number of equivalents}}{\text{liter of solution}}$	$\text{eq} \cdot \text{L}^{-1}$

Metric Prefixes

Prefix	Abbreviation	Multiplier
yotta	Y	10^{24}
zetta	Z	10^{21}
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^9
mega	M	10^6
kilo	k	10^3
hecto	h	10^2
deka	da	10^1
deci	d	10^{-1}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}

Lab Tips

Stock solutions

Keep the label away from the direction you are pouring when using bottles that contain stock solutions.

Never pour solutions back into the stock solution.

Equipment List

You will be using some glassware on a regular basis. You should find the following pieces of equipment in the drawer assigned to you.

- test tubes (9-12)
- 1000 mL beaker
- 250 mL beakers (2)
- 100 mL beakers (2)
- 125 mL Erlenmeyer flasks (3)
- 300 mL Erlenmeyer flasks (2)
- 10 mL graduated cylinder
- 100 mL graduated cylinder
- disposable pipet
- funnel
- clamp extension
- double clamp
- test tube brush
- test tube holder

Pipets and Pipet Pumps

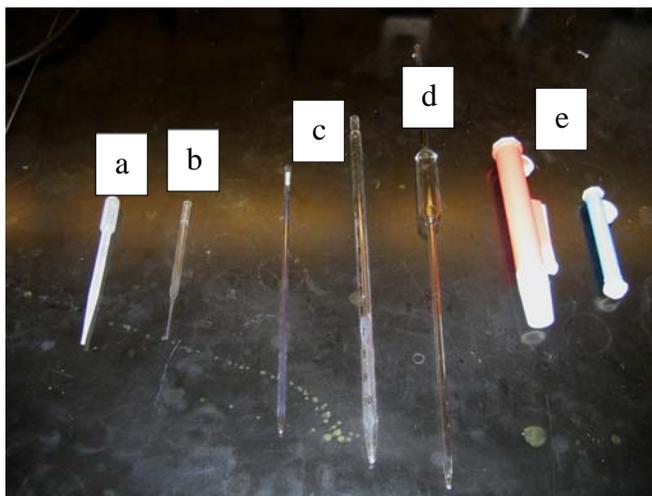
Pipets and pipet pumps are used for transferring liquids. There are several types of pipets. A few that are used in general chemistry are shown below. Pipets are generally available in two forms, TD and TC.

TD means to deliver. These types of pipets may have an internal volume that is greater than the volume delivered. These pipets are calibrated in the factory to release the desired quantity of liquid. When the liquid pours out of the pipet there may still be some liquid visible on the inside. If the pipet is marked TD then the fact that there is liquid remaining is normal.

TC means to contain. This means that the total volume in the container is the volume indicated on the glassware.

a. Disposable transfer pipette. These pipets are made of plastic and are useful for transferring liquids dropwise.

b. Disposable glass Pasteur pipet. These pipets are also used for transferring liquids dropwise.



c. Disposable glass or plastic serological pipets. These pipets possess markings that allow measured quantities of liquids to be transferred. They are often used when the amount of liquid being transferred must be known.

d. Volumetric pipet. These glass pipets are used to transfer liquids when the quantity of liquid must be known to a high degree of accuracy. These pipets are used to transfer one fixed volume such as 1 mL or 10 mL.

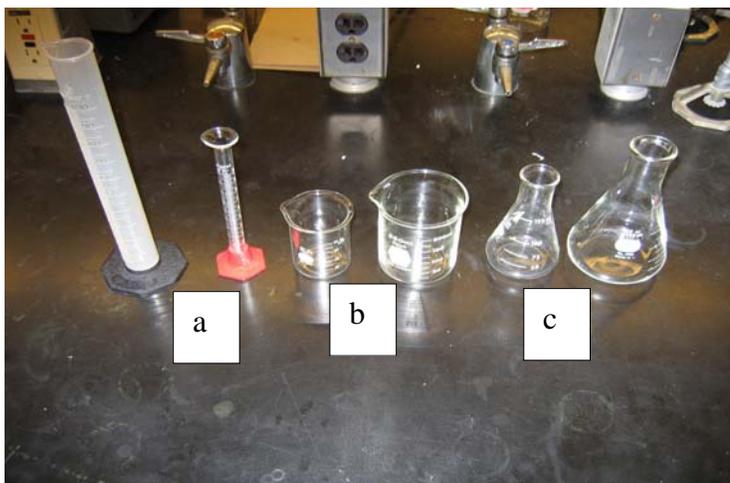
e. Pipet pumps. These are used with the serological or volumetric pumps. The pump is placed at the top of the pipet and forms a vacuum above the liquid, causing the liquid to rise into the pipet.

Graduated Cylinders, Beakers, and Erlenmeyer Flasks

a. **Graduated cylinders** are used to transfer liquids with a moderate degree of accuracy.

b. **Beakers** are used as containers. They are available in a variety of sizes. Although they often possess volume markings, these are only rough estimates of the liquid volume. The markings are not necessarily accurate.

c. **Erlenmeyer flasks** are often used as reaction vessels, particularly in titrations. As with beakers, the volume markings should not be considered accurate.

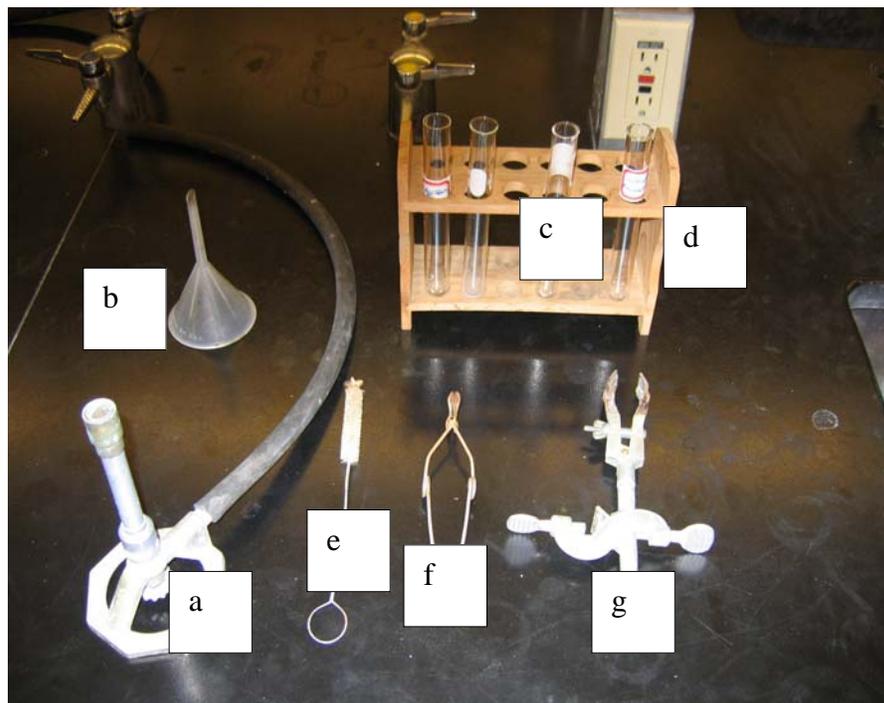


Volumetric flasks are used to measure and store solutions with a high degree of accuracy. These flasks generally possess a marking near the top that indicates the level at which the volume of the liquid is equal to the volume written on the outside of the flask. These devices are often used when solutions containing dissolved solids of known concentration are needed.

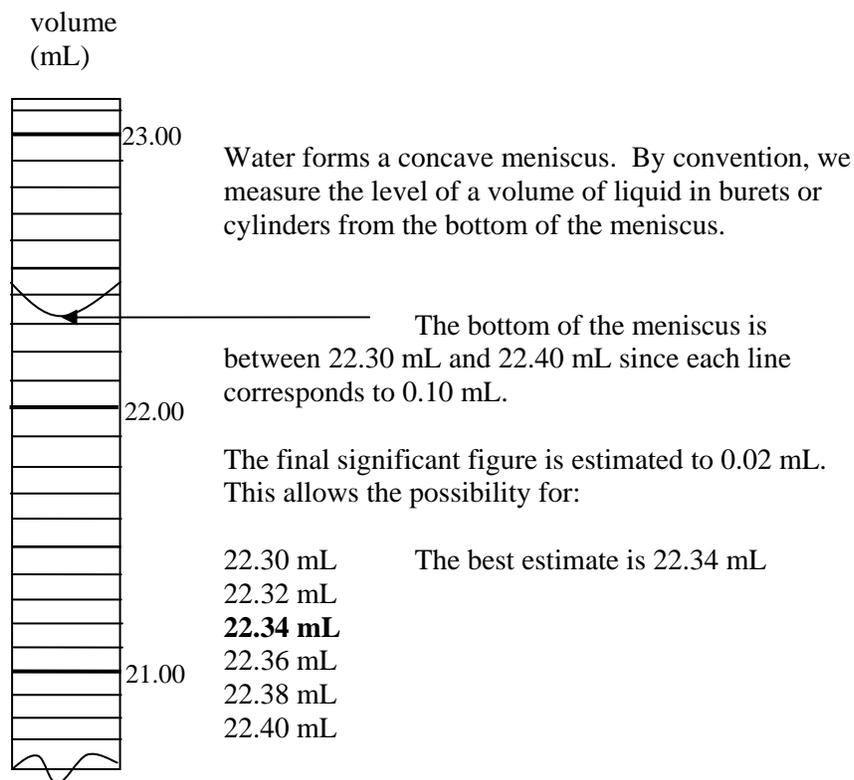


Additional Equipment

- a. Bunsen burner.
- b. Funnel.
- c. Test tubes.
- d. Test tube rack.
- e. Test tube brush.
- f. Test tube holder
- g. Clamp and clamp extension.



Estimating the Volume of a Liquid in Burets, Pipets, and Graduated Cylinders



In burets and pipets it is common to measure the volume delivered. This means that two volume measurements will be made. The volume delivered is the difference in these two volumes, $V_{\text{final}} - V_{\text{initial}}$

Operating Instructions for the Spectronic 301 Spectrophotometer

1. There are two common modes of operation, ABSORBANCE and PERCENT TRANSMITTANCE. We will make most measurements in the ABSORBANCE mode. The absorbance mode is shown by a red light next to the letters **ABS** in the display. If the red light is next to any other mode, press the **SECOND FUNCTION** and **8(ABS)** keys. This will move the instrument into the ABSORBANCE mode.
2. The numbers in the display show the current wavelength and the absorbance value. For example, the display below shows readings of 525 nm and an absorbance of 0.201:

WAVELENGTH	DATA
525	0.201

3. Most measurements are made in a 1 cm square cuvette. To measure samples in the cuvette, open the front cover of the instrument and place a square plastic cuvette that contains the blank solution in the cuvette holder. Be sure that the cuvette is oriented so that the clear sides face front and back, and the outside surface is dry. Close the front cover.
4. To set the wavelength: Enter a 3 digit number for the wavelength (in nanometers). Select **GO TO λ** , which is the up arrow key on the keypad. The desired wavelength should now be shown, along with an absorbance reading.
5. The blank should be set to an absorbance of zero. To do this, press **AUTO ZERO** on the keypad. The absorbance value should now display **0.000**.
6. Open the front cover. Remove the blank cuvette. Then insert the sample cuvette into the cuvette holder. Be sure that the cuvette is oriented so that the clear sides face front and back. Close the front cover.
7. The absorbance will appear on the digital display. Enter this absorbance value in your data sheet.
8. Remove the sample cuvette. Insert the blank cuvette. Set the wavelength to the next desired value as described in step #5 above