Appendix A: Use of Lab Equipment and Lab Sign-Out

Use of Lab Equipment

You will be assigned equipment drawer(s) in the laboratory. To use this equipment for performing lab experiments, you must indicate acceptance of responsibility for the equipment in this drawer by signing the Lab Drawer Assignment Sheet.

Certain experiments may require additional equipment which you will sign out at the start of the lab by completing a Supplementary Equipment Sheet. In addition, each laboratory contains instruments and communal equipment in labeled drawers that may be used as required. The communal equipment must be returned, clean and undamaged to the appropriate locations at the end of each lab period.

Once you have signed the drawer assignment sheet and supplementary equipment sheet, you are required to:

- report all damaged and/or lost equipment to the lab instructor.
- collect replacement from the lab technician before the end of the lab period.
- place said replacement in your equipment drawer and/or the supplementary equipment tray which you signed out.
- lock drawer, return equipment tray and sign the supplementary equipment sheet before leaving the lab.

By signing the drawer and supplementary equipment sheets, **you become responsible for the replacement cost** of ALL damaged or lost equipment in which you have signed out and communal equipment and instruments which you have used. Equipment from the Supplementary Equipment Trays, if reported lost or broken in **the first 30 minutes** of the lab period, will be charged against the student(s) who last used the Supplementary Equipment Tray.

You also accept that you must sign out of your equipment drawer on the last scheduled lab – or when withdrawing early from the course – and that you are liable for the equipment replacement costs that you may have accumulated. **A $30.00 fee will be charged to students who fail to sign out of lab**.

Laboratory Sign-Out

At the end of term or when withdrawing early from the course, students must sign out of the assigned equipment drawer.

Sign-out involves cleaning the equipment and getting the TA or lab technician to check contents of the drawer. After the inspection, both the student and lab instructor (or technician) will sign the Lab Drawer Assignment Sheet to complete the lab Sign Out.

All students, **even those who withdraw early from the course**, MUST sign out of their registered lab sections before the last day of lectures of the term. Students who fail to sign out will be assessed a charge of $30.00 plus the accumulated replacement cost of equipment that they had damaged or lost. If this fee is not paid by the last day of the final examination period of the term, an additional $10.00 administrative fee will be charged and **university services (registration, transcripts, etc.) may be withheld.**

Appendix B: CHEM 209 Student Equipment List

	Student Drawer Equipment	Unit Cost ($)
4	beaker, 50 mL	4.00
2	beaker, 100 mL	2.00
2	beaker, 150 mL	2.00
2	beaker, 250 mL	3.00
2	beaker, 400 mL	3.00
1	brush, large 2.5 cm	4.00
1	brush, medium 1.9 cm	4.00
1	burette funnel, short narrow stem	2.00
1	Chemistry combination lock	10.00
2	conical flask, 50 mL	5.00
4	conical flask, 250 mL	5.00
1	filter funnel, long narrow stem	10.00
3	graduated pipette, 10 mL	14.00
1	marking pen	2.00
1	measuring cylinder, graduated, 100 mL	10.00
1	medicine dropper	1.00
1	pipette filler bulb, blue	8.00
2	safety glasses, clear lens with side shield	10.00
1	spin magnet, 5/16” x 1"	2.00
1	stirring rod, 200-250 mm	2.00
1	titration tile, white	2.00
1	volumetric flask stopper, size 13	4.00
1	volumetric flask stopper, size 16	4.00
1	volumetric flask, 100 mL	20.00
1	volumetric flask, 250 mL	25.00
1	volumetric pipette, 5 mL	6.00
1	volumetric pipette, 10 mL	6.00
1	volumetric pipette, 25 mL	13.00
4	watch glass, 100 mm	4.00

Appendix C: Laboratory Fees & Communal Equipment

Lab Fees & Other Lab Equipment Cost	**Unit Cost ($)**
Lab Fees: Failure to check out	30.00
Failure to report damaged and lost supplementary equipment (per person per group)	5.00
Science Workshop repair (per hour, cost of parts extra)	20.00
ULT to Clean Equipment (per piece)	5.00
2-prong clamp, 78 mm	23.00
3-prong clamp, 105 mm	34.00
3-prong clamp, 69 mm	30.00
3-prong clamp, 69 mm long extension	48.00
balance, Mettler-Toledo MS303S	2,338.00
bottle top dispenser, Brinkmann	671.00
bottle top dispenser, Fisherbrand	125.00
burette clamp	50.00
burette, 50 mL 3 pcs set *burette barrel, 50 mL $ 27.00* *burette glass tip $ 9.00* *burette PTFE stopcock $ 72.00*	92.00
glass bottle, Boston round, for unknown sample	2.00
clamp holder for 3-prongs clamp	15.00
hot plate, ceramic top plate 10 x 10"	516.00
magnetic stirrer	285.00
multi-meter test clip, black or red	11.00
multi-meter 15XP	119.00
pH Electrode, InLab® 3-in-1	320.00
pH electrode stand	52.00
pH meter, Mettler-Toledo	698.00
plastic beaker/cup	1.00
rubber stopper	2.00
silver wire electrode (*if not returned*)	6.00
spectrophotometer, Genesys 10 vis	4 452.00
dispensing/measuring spoon	2.00
stopwatch	23.00
support holder clamp for glass filter funnel	32.00
support stand, triangular base 36" rod	71.00
test tube clamp holder	3.00
test tube rack, 25 mm	9.00
test tube	2.00
test tube (*if not returned*)	3.00

Appendix D: Periodic Table & Prefixes for SI Units

1 1A																	18 8A
1 **H** 1.008	2 2A					**Legend:** 1 **H** 1.008 ← Atomic number (Z) ← Atomic symbol ← Atomic mass (amu)						13 3A	14 4A	15 5A	16 6A	17 7A	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31	3	4	5	6	7	8	9	10	11	12	13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.38	31 **Ga** 69.72	32 **Ge** 72.59	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57* **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.0	89** **Ac** (227)	104 **Rf** (261)	105 **Ha** (262)	106 **Sg** (263)	107 **Ns** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Uun** (269)	111 **Uuu** (272)							

Lanthanides *	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
Actinides **	90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.0	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

Prefixes for SI Units

The following prefixes may be used to indicate decimal fractions or multiples of the basic or derived SI units. Multiples of units are normally to be restricted to steps of a thousand and similarly fractions to steps of a thousandth.

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

Appendix E: Treatment of Numerical Data

In most laboratory experiments, you will gather numerical data as part of your procedure, and will need to "work up" or analyze this data. Proper data analysis will not only tell you the final result of your experiment, but will allow you to describe the **accuracy** and **precision** of your results.

Precision of Measured Values

Precision is a measure of the reproducibility of the measured value of a quantity. It can be thought of as the "spread" or deviation of your observed measurements as compared to the true value of the quantity being measured. Figure E.1 illustrates an example of precise and imprecise measurements. Both sets of measurements (as represented by the dots) are clustered around the centre point (the true value). However, the measurements in (a.) are more spread out – they are less precise.

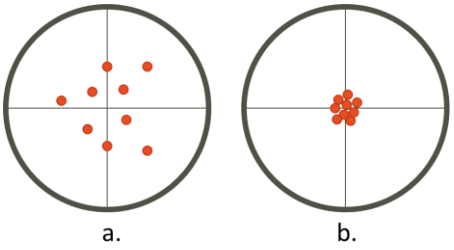


Figure E. 1: Depiction of measurements that are relatively (a.) imprecise and (b.) precise, compared to the 'true' value at centre.

A more precise data set is usually better, as it indicates that there is less *random error* (discussed below) affecting your measurements.

Typically, we will describe the precision of measurements in the laboratory in two ways: by tracking **significant figures** or by reporting **standard deviation** of a data set.

Significant Figures

For some observations, precision of the measurement is not a problem – if you are asked to count the number of oranges in a box, you will produce an exact number. However, most measurements you will make have some degree of uncertainty (or error) associated with it. For example, if you weighed an orange you may record a mass of 96.247 g. If you remove the orange and replace it on the balance, it may register 96.246 g on the next weighing. Like the slight change in the observed mass of the orange, there is some **uncertainty** in the value reported of any measurement.

When reporting measurements in the laboratory, we typically report values such that the *uncertain digit* – that is, the first digit that is likely to change with a repeated measurement – is the final reported digit. Unless otherwise indicated, it is assumed the uncertainty in the final digit of a measurement is ±1. For the orange's mass described above, the uncertainty is in the 3rd decimal place, and we can say that the mass is correct to five significant digits overall. Typically, "leading zeroes" – those to the left of the first non-zero number in a value – are not significant. For example, the number 0.0004020 has only four significant digits (underlined).

When you are combining measurements and manipulating data in the lab, you will need a way track the precision of these values as they are changed via calculations. One simple way to do this is through the use of **significant figures**, and applying the rules below.

Rules for Significant Figures

1. Raw data and the final reported value retains only **one uncertain or estimated digit**. Intermediate calculations can (and should) contain additional uncertain digits in order to reduce errors caused by rounding-off.
    - There are a few conventions for carrying 'extra' digits when writing intermediate values. You can underline the last significant digit in the value (96.245931) or use subscript for the 'extra' digits (96.245_{931}).
2. When determining the result of an addition or subtraction, the precision of your answer is determined by the initial value with the **fewest decimal places**:

e.g. *7246.14 m* + *56.7804 m* = *7302.9204* = *7302.92*

2 decimal places | **4** decimal places | Unrounded answer | Final value

**least precise value*

(make sure all values are in the same unit before comparing!)

2 decimal places

Final precision matches the least precise initial value (absolute precision)

For very large or small values, it may be helpful to use scientific notation (make sure all values are expressed to the same power, even if this makes "improper" scientific notation):

e.g. 1.632×10^5 J + 4107 J

163.2×10^3 J 4.107×10^3 J = 167.307×10^3 J = 167.3×10^3 J

**write both to the same power of 10*

Least precise value has **1** decimal place

1 decimal place in final answer

Note: It is possible to have a final answer that has **more** significant figures than either of the original value when adding or subtracting. (try calculating the formula mass of KrF_2: 18.998 g/mol + 18.988 g/mol + 83.798 g/mol)

3. In multiplication or division, the uncertainty of the final result should match the **fewest overall significant figures** of any of the initial values:

e.g. *10.67 s* × *1.01 A* = *10.7767 C* = *10.8 C*

4 sig. figures | **3** sig. figures | Unrounded answer | Final value

**least precise value*

3 significant figures

Final precision matches the least precise initial value (relative precision)

e.g. *10.46 N* ÷ *10.760 m^2* = *0.9721189591… Pa* = *0.9721 Pa*

4 sig. figures | **5** sig. figures | Unrounded answer | Final value

**least precise*

4 significant figures

4. For logarithms (such as pH) and antilogarithms, the number of significant figures in the *mantissa* of the logarithm (the part after the decimal point) should match the number of significant figures (total) in the antilogarithm:

e.g. *log(3.2)* = *0.505149978…* = *0.51*

2 sig. figures | Unrounded logarithm | **2** significant figures in mantissa

e.g. *log(1237)* = *3.0923697* = *3.0924*

4 sig. figures | Unrounded logarithm | **4** significant figures in mantissa

**Digits before the decimal are not significant in a logarithm.*

**Leading zeroes in the mantissa are significant.*

e.g. $10^{4.37}$ = *23442.28815…* = *23000* = 2.3×10^4

2 sig. figures in mantissa | Unrounded antilogarithm | **2** significant figures in antilogarithm

There are more rigorous ways to track uncertainty through your calculations that you will use in other courses, but following these significant figures rules gives a quick estimate of the overall uncertainty that is appropriate for most situations.

Rounding-off

At some point, you will have to round off calculated values to express the answer with the correct number of significant figures. To minimize error introduced during rounding, the following criteria are suggested:

- When the first 'extra' figure is less than 5, the last significant figure remains unchanged.
  - e.g. 5.6$\underline{7}$2 → 5.67
- When the first 'extra' figure is greater than 5, the last significant figure is increased by one.
  - e.g. 5.6$\underline{7}$7 → 5.68
- When the first 'extra' figure is exactly 5, the last significant figure remains unchanged if it is even, and is increased by one if it is odd.
  - e.g. 5.6$\underline{7}$5 → 5.68
  - e.g. 5.6$\underline{8}$5→ 5.68

Standard Deviation

The spread or scatter of experimental data around its average can be measured with the **standard deviation** (also called *statistical precision*), *s*. Standard deviation can be calculated:

$$s = \sqrt{\frac{\sum(M_i - \bar{M})^2}{n-1}}$$

Where: M_i is an individual measurement or observed value
$\bar{M}$ is the mean (average of all observed values)
n is the total number of measurements
Σ means "sum of" – in this case indicating to sum all of the $(M_i - \bar{M})^2$ values.

A larger standard deviation indicates a lower precision in that measurement set (a larger 'spread' in the measurements). For more detail on using standard deviation as a measure of experimental uncertainty, see Chapter 4-1 from D.C. Harris, *Quantitative Chemical Analysis*, *9th ed.* W.H. Freeman: New York, 2016.

Accuracy of Measured Values

Accuracy describes how close a measured value is to the "true" value. While some measurements may have high precision and be very reproducible, their result may be wrong. Figure E.2 shows such an example with two sets of measurements, both with approximately the same reproducibility. The measurements in a. are relatively accurate, as the measurements are centred around the true (centre) value. The measurements in b., while reproducible (good precision) are less accurate, since their average value is not close to the true value.

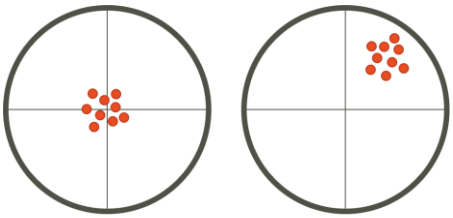


Figure E. 2: Depiction of measurements that are relatively (a.) more accurate and (b.) less accurate, compared to the 'true' value at centre.

Ideally, your measurements will be both very accurate and very precise. However, there are limits to how accurate or precise any chemical technique can be. You can get a sense from Figure E.2 that one way to increase accuracy is to take the average of several measurements – the measurements taken individually all have some 'scatter' or error relative to the true value – but taken together, the average should be closer to the true value than any single measurement is likely to be.

If the true value is known (e.g. as a trusted 'literature value' previously determined), accuracy can be expressed as **percent error**:

$$\%\ error = \frac{|observed\ value - true\ value|}{true\ value} \times 100\%$$

Types of Errors

There are two main types of errors encountered in measurements: systematic and random errors.

Systematic errors lead to a loss of accuracy but not necessarily precision. These errors arise from a flaw in the procedure or the equipment used – for example, an instrument may consistently give a result that is too low, or a reaction is assumed to go to completion when it actually does not. Using impure reagents, poor experimenter technique, and personal limitations such as color blindness can also cause systematic errors. Often, this type of error can be reduced by measuring a reference sample or performing a calibration on the instrument used.

Random errors lead to a loss in precision but not necessarily accuracy. This type of error can be reduced by refining procedures, but never completely eliminated, since there are always uncontrollable variables– for example, friction in a balance leading to slight variations in repeated measurements. Since random error causes variation about an average value, repeated measurements and analysis by mean and standard deviation allow random error to be described statistically.

Outliers in Experimental Data

Occasionally, due either to random error or a mistake by the experimenter, one measurement in a data set is very different from the rest (like the blue point in Figure E.3). Such data points are called **outliers**. Outliers in a measurement set increase the uncertainty of your final values, and could bias your final result. However, first it must be determined whether an apparent outlier is *truly* an erroneous value should and should be eliminated, or whether it is only slightly farther from average than the rest, and be kept (representing the random error in your measurements.

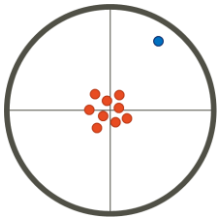


FIGURE E. 3: SAMPLE DATASET INCLUDING AN OUTLIER (BLUE)

If you know a specific error was made during a measurement (e.g. an overshot titration) **always discard** the data point.

If a data point is suspect, a quick way to determine if it is an outlier is to compare it to the measurement average using the standard deviation. If a data point is **more than ±3*s* from the mean**, it is likely an outlier, and may be safely discarded. For a more rigorous method of determining whether a data point is an outlier, the **Grubbs test** may be used.

The Grubbs Test

1. Calculate the value *G* based on the entire data set *including the outlier*:
   $G_{calculated} = \frac{|questionable\ value - \bar{x}|}{s}$
   where $\bar{x}$ is the mean of the data set, and *s* the standard deviation.

2. Compare $G_{calculated}$ to the tabulated values of *G* for a 95% confidence limit (Table E.1). Use the value that best corresponds to the number of observations in your data set.

3. If $G_{calculated} > G_{table}$ then you can be at least 95% certain that the questionable data point is actually an outlier and you can **discard** the questionable point.
   If $G_{calculated} < G_{table}$ then there is more than a 5% chance that the questionable point is a 'true' measurement, and you should **keep** the questionable value in your data set.

TABLE E. 1: CRITICAL VALUES OF G

Number of observations	G_{table} (95% confidence)
4	1.463
5	1.672
6	1.822
7	1.938
8	2.032
10	2.176

4. If you discarded the questionable point, recalculate the mean and standard deviation for your data set, *without* the outlier, before doing further calculations.

Since most of the data sets you will deal with in this course are small, **never discard more than one data point** as an outlier, whether using *s* or the Grubbs test. Discarding multiple points can increase the uncertainty in your data set overall.

Appendix F: Balances and Weighing

Top Loading Balances

Most modern balances are of this type, but different models vary considerably in precision and accuracy.

Directions for Use

1. Check that the balance is levelled and adjust if necessary.
2. Normally the balance is ready with the display on. If this is not the case, consult your instructor.
3. The display should show 0.000 g. If it does not, re-zero by pressing the appropriate button.
4. **Very carefully** place the object to be weighed on the pan and read the weight.
5. If the object is a container and you wish to tare it, re-zero with the empty container on the pan. The display will again show zero. Add the material/object to be weighed to the container and read the weight.
6. Re-zero the balance after use, so it is ready for the next student.

Rules for Use of the Balances

1. No powdered material should ever be placed on the pan. All substances must be weighed in appropriate weighing containers such as weighing bottles, weighing paper, watch glass etc. Solids or liquids sticking to the outside of the weighing container will damage the balance and make the reading inaccurate. For the same reasons make sure that the weighing object is at room temperature when you weigh.
2. The balance must be kept spotlessly clean. The pan and surrounding area within the draft shield should be brushed to remove any solid particles.

Appendix G: Volumetric Apparatus

A volumetric apparatus is one that is designed to deliver or contain exact volumes of liquids. Calibration of the volume is to two decimal places for a specific temperature and is etched on to the side of the apparatus. Reading the following sections will help you to learn the proper use of volumetric equipment.

Part I - Cleaning of volumetric glassware

It is always a good practice to clean any used glassware at the end of every laboratory period before putting it away. This will save time during the next experiment.

If volumetric glassware is cleaned immediately prior to use it is not necessary to dry it. Most of the time the glassware is used for aqueous solutions so that rinsing the glassware with the desired solvent before use is sufficient. In chemistry 201 all solutions will be aqueous therefore rinsing with RO[1] water is sufficient.

Part II - Types of Glassware

Volumetric Flasks

Volumetric flasks are used to prepare solutions of definite concentration. They are calibrated to **hold** an exactly known, fixed volume.

Solutions can be prepared by one of the following methods:

A. Weighing a pure solid and dissolving it in known volume

The solid is ***weighed by difference***. Weight of the weighing bottle and solid is recorded, then the solid is transferred into a beaker; the bottle and residue are reweighed and the difference is the weight of solid used to make the solution.

The solid is ***quantitatively transferred to a CLEAN volumetric flask*** by dissolving it in a small amount of the desired solvent. The solution is transferred to a volumetric flask, the beaker is rinsed several times with the desired solvent and each rinsing is transferred into the volumetric flask (make sure to use a funnel when pouring the liquid into the volumetric flask) to ensure complete transfer of the solid. The flask is filled half way with the appropriate solvent. It is swirled to ensure mixing of solutions and then filled or diluted close to the “mark” with solvent (a “mark” is a line etched into the neck of a volumetric flask, when the bottom of the meniscus of the solvent is level with this line the flask is said to contain its desired volume). The final adjustment to the mark is made by adding the solvent using a medicine dropper. The solution is then mixed thoroughly by inverting the flask many times (at least six) with a simultaneous rotary motion.

B. By dilution of a more concentrated solution

The appropriate volume of the stock solution is pipetted (See Pipettes) into a volumetric flask. The flask is half filled with the appropriate solvent. It is swirled to ensure mixing of solutions and is then "made up to the mark" with solvent.

Volumetric flasks and their contents should be stoppered when not in use in order to minimize contamination of the solution and evaporation of the solvent.

[1] RO = reverse osmosis. To prepare RO water, pressure is used to force water through a membrane which filters out various solutes (e.g. metal ions) from the water.

Pipettes

There are two types of pipettes you may encounter, volumetric and graduated. The former is calibrated to deliver an exactly known, fixed volume and the latter to deliver an exactly known volume that can be varied from one application to the next. The sample a pipette delivers is known as an *aliquot*.

Proper use of a pipette:

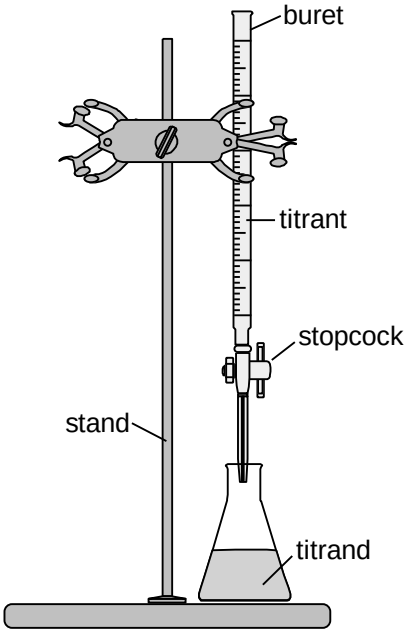
Never pipette by mouth. A pipette bulb is used to draw liquids up into a pipette.

1. A CLEAN pipette must first be rinsed with the solution to be pipetted. In order to avoid contamination of prepared solutions, whether for rinsing or measuring small volumes of the prepared solution (~20 mL) should be transferred from the container in which it was prepared to a small CLEAN beaker for pipetting.
2. Squeeze AND HOLD the pressure to the pipette bulb to expel as much air as possible from the bulb.
3. Place the open end of the pipette bulb squarely on the top of a pipette. There must be a good seal between the pipette and the bulb.
4. Submerge the tip of the pipette below the surface of the solution to be pipetted but without touching the bottom of the beaker.
5. Slowly release pressure on the bulb to draw up the liquid into the pipette. For rinsing one needs only fill the pipette to about 1/3 its volume; if pipetting sample for an experiment one needs to draw the liquid above the "mark" (etched line on a pipette that indicates the level for the appropriate volume of solution).
6. Once the desired amount of liquid has been drawn up, use the index finger to close the top of the pipette. (this finger can be controlled far more accurately than a thumb).
7. Remove the tip of the pipette from the solution and wipe tip with lint free Kimwipe.
    a. ***If rinsing***, tip the pipette sideways, remove your index finger and rotate the pipette (horizontally) in your hands to ensure the liquid within wets all surfaces of the pipette. Use index finger to close the top of the pipette again and hold it upright. Place the tip of the pipette against the wall of a waste beaker and remove your index finger to drain the liquid. The pipette is rinsed with two or three small volumes (~5 mL) before measuring for an experiment.
    b. ***If measuring for an experiment***, after drawing the liquid above the “mark”, place the tip of the pipette against the wall of a waste beaker and release your index finger slightly such that liquid in the pipette starts to flow out. Allow the liquid to fall until the meniscus is level with the "mark". Reapply index finger to the top of the pipette such that the liquid stops flowing.
8. Dispense contents of the pipette into the desired container by touching the pipette tip against the wall of the container and releasing your index finger from the top of the pipette. Do not apply pressure to a pipette bulb to speed up the draining.
9. Once the liquid has drained out there will be a small drop remaining in the tip of the pipette. Some pipettes are calibrated to include this drop others are not. Make sure you know which is the case for the pipette that you are using. If the pipette has a single line etched at the top, it is calibrated *to dispense*, DO NOT BLOW OUT THE REMAINING DROP IN THE PIPETTE TIP. If the pipette has a double line etched at the top, it is calibrated to contain, you must blow out the remaining drop.

At the end of a laboratory period you should clean and rinse the pipette with distilled water for storage.

Burettes

Similar to a pipette, the sample a burette delivers is also known as an aliquot. Burettes are calibrated to **deliver** known volumes that can be varied from one application to the next. In the first year laboratories a burette will be used to dispense some of the more hazardous reagents and to do quantitative analyses known as titrations.



Proper use of a burette:

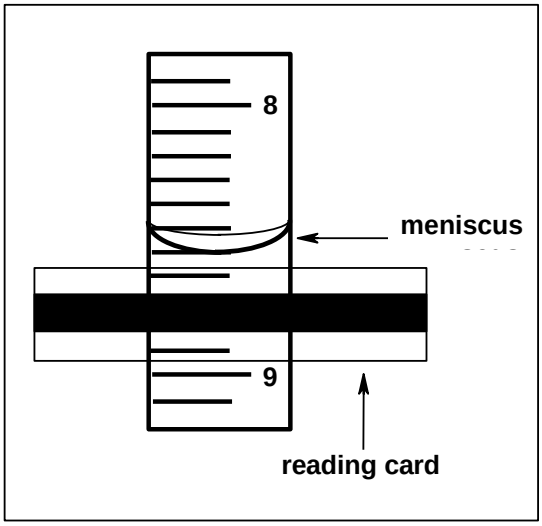
1. Make sure that the burette tip is securely attached to the stopcock and the stopcock in turn securely attached to the graduated body (barrel) of the burette. The barrel is then placed in a burette clamp attached to a retort stand.
2. Before use, a CLEAN burette must first be rinsed with the solution to be dispensed.
3. A burette funnel is placed on the top of the burette. Two or three small portions (~5mL) can be successively poured down through the funnel and allowed to drain slowly out.

   Alternatively, the stopcock may be closed, a small sample poured into the body of the burette, the burette removed from its holder, tipped sideways and rotated (to make sure the entire surface of the burette is rinsed with solution) and then the solution drained out.
4. To fill a burette for dispensing or titration, make sure the stopcock is closed. Through the burette funnel pour the solution to be dispensed until the level of its meniscus is above the zero graduation mark.
5. Rapidly turn the stopcock, which will open the burette briefly to fill the tip and remove any air bubbles in the stopcock or tip.
6. Adjust the level of titrant in the burette to zero or just below the zero point (the initial reading in a titration needs not be exactly zero as any volume dispensed can be accurately determined). Touch the tip of the burette to the side of the waste beaker to remove the last drop.
7. Read and record the initial volume.
8. Turn the stopcock and dispense the required amount of solution.
9. Read and record the final volume. The actual volume dispensed will be the difference between the initial and final volumes.

Reading a burette: The precision of a burette reading can be made to within ± 0.01 mL by using a burette reading card.

The burette reading card is a white card with a black strip on it. When this card is brought to the back of a burette behind the meniscus of a clear solution, the bottom of the meniscus darkens. This increases the accuracy of a reading. When the card is brought close enough so that the bottom edge of the darkened meniscus is equal in intensity to the lines of graduation etched on the burette, both the thickness of the meniscus is now said to be equal to 0.01mL in measurement.

A burette reading card is unable to be used effectively with an opaque liquid. The top of the meniscus is now read off the burette so the accuracy of readings is less.



Additional comments if using the burette in a titration:

- The container (usually an Erlenmeyer flask) that contains the *titrand* (solution to be titrated) should be placed on top of a white tile (so that colour changes occurring during the titration may be seen more easily).
- The "best" designed titrations will require almost a full burette of the *titrant* (solution in the burette) to be dispensed to reach an endpoint.
- The *titrant* is first dispensed rapidly from the burette. At the same time the titrant is dispensed the titrand is being continuously swirled (If right handed, the container is swirled with the right hand while the left hand is kept on the stopcock).
- The first few drops of titrant will cause a localized colour change that disappears very quickly. Each successive drop will give a more persistent colour change. As the rate of colour change slows so should the rate of addition of titrant.
- When the end-point (or pale, permanent colour change) is imminent, the titrant should be added one drop (or sometimes even less) at a time. After each drop, the tip of the burette is touched to the top of the container for the titrand and the titrant released is then washed down the neck/walls of container with a small volume of distilled water from a wash bottle.
- If a good end-point is obtained, save the completely titrated solution for comparison with replicate titrations.

At the end of a laboratory period you should clean and rinse the burette with distilled water for storage.

Appendix H: Genesys Spectrophotometer

Genesys Spectrophotometer

1. Turn on the Spectrophotometer using the on/off switch at the back of the instrument,

2. To change between Absorbance and Transmittance and other mode of measurement methods, press “Change Mode”. Measurement mode will appear on the top left corner of the display screen.

3. To adjust the wavelength of light, press “Set nm” and enter the desired wavelength using the number keys. Press “Enter” to accept wavelength number and exit.

4. To measure a blank sample, pour the solution to be measured into a glass cuvette until the tube is approximately half full. Wipe the outside of the cuvette with a Kimwipe and load it into position “B” in the cell holder. Close spectrophotometer’s cover. Press “Measure Blank”.

5. To measure transmittance of a sample, wipe the cuvette with a Kimwipe, load it into, for example, position 1 in the cell holder. Close spectrophotometer cover and press cell position button “1”. The transmittance measurement will appear on the display screen.

APPENDIX I: Mettler-Toledo pH Meter

- Before immersing pH electrode (probe) in a solution, always rinse it with plenty of RO water.
- Always keep pH electrode immersed in solution or RO water.
- Do not wipe sensing bulb of the electrode with Kimwipe.

Two-Point Calibration using Auto-Averaging ("A") mode:

During the calibration procedure, always keep the pH electrode immersed in buffer solution or RO water.

1. Turn pH meter on.
2. Check if buffer calibration range B4 is displaced [*B4 6.86 4.01 9.18 1.68*]. Consult TA if it is not.
3. Rinse a clean 50 ml beaker with ~10 mL of pH 9 buffer. Discard the rinse solution and add another ~30 mL of this buffer to the beaker.
4. Take a second clean 50 mL beaker and repeat step 3 with pH 4 buffer.
5. Make sure there is an "A" on the right hand side of the pH meter screen. If not, press Read and hold until the "A" appears.
6. Remove pH probe from the storage bottle and immerse it in the pH 4 buffer about 1.5-2 cm below the surface of the liquid. Swirl the solution and wait for temperature of the solution to stabilize. A pH value will appear. When the decimal point on the pH value stops blinking, pH of the solution has stabilized.

7. Press the CAL key. "CAL1" will flash next to the temperature value on the screen of the pH meter. When "CAL1" stops flashing, a symbol ⌜ will appear over the "A" (⌜A). At this time, first calibration point is confirmed.
8. Remove the pH probe from pH 4 buffer, rinse it with RO water and immerse it in the pH 9.18 buffer about 1.5-2 cm below surface of the liquid. Swirl the solution and wait for its temperature to stabilize. When the decimal point on the new pH value stops blinking, pH of the solution has stabilized.
9. Press CAL again. "CAL2" will flash on the screen of the pH meter. When "CAL2" stops flashing, the symbol ⌜ will appear over the "A" (⌜A). Second calibration point is confirmed and the two-point calibration procedure is completed.
10. Remove the probe from the buffer, rinse it with plenty of RO water and store in a beaker of RO water.

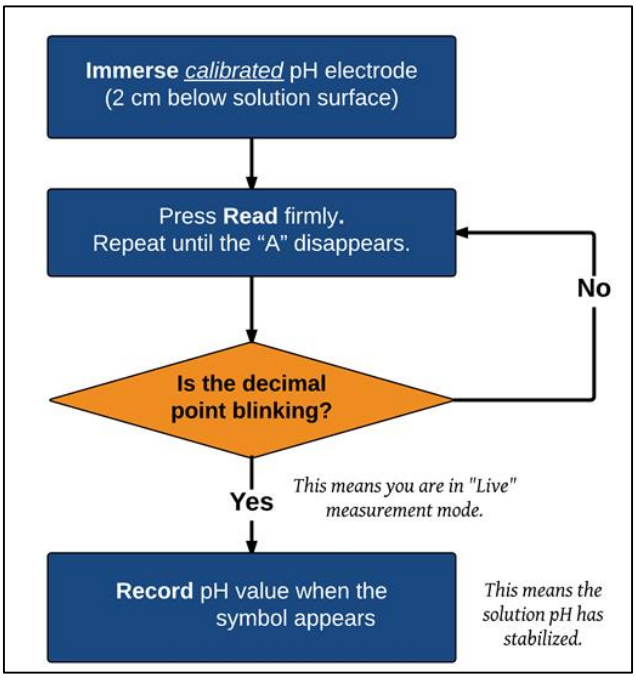
Single point pH measurement using Auto-Averaging mode

1. Make sure "A" is displayed on the screen of the pH meter screen. If not, press Read quickly a few times until it appears.
2. Immerse the calibrated pH electrode in the sample solution about 1.5-2 cm below surface of the liquid. Swirl the solution. Press READ; do not hold the button. Some pH values will appear. When the pH of the solution has stabilized, the decimal point on the pH value will stop flashing and ⌜ will appear over the "A" on the right hand side of the screen (⌜A).
3. This is the auto averaged pH value of your solution. Note that when ⌜A is displayed on the screen, pH value will not change until READ is pressed again.

Continuous or "Live" pH measurement

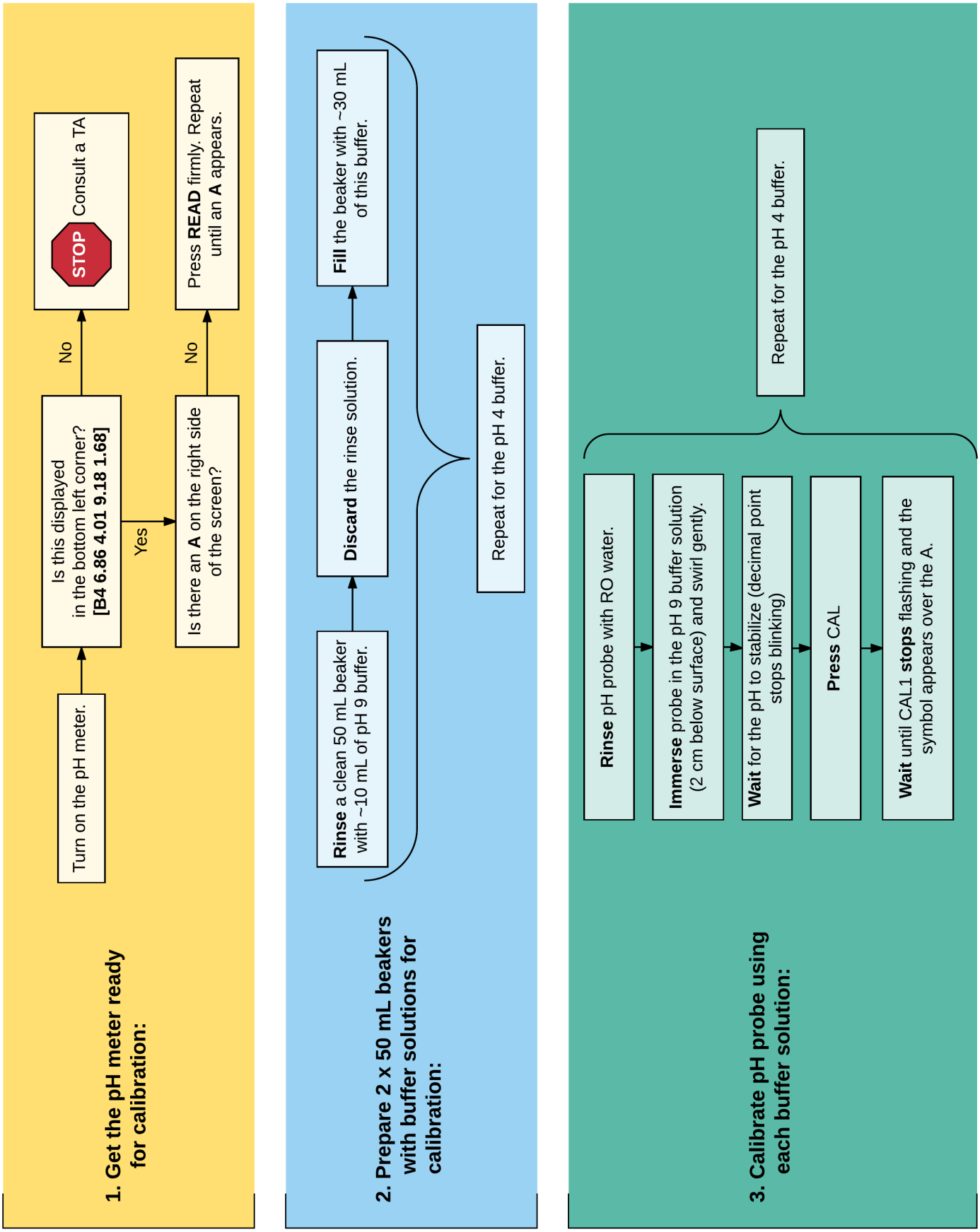
If you want to observe the pH value of your solution as it is changing (e.g. during a titration), the pH meter must be set to "Live" mode.

1. With the calibrated pH electrode in the sample solution about 1.5-2 cm below surface of the liquid, press and hold READ until "A" disappears from the right hand side of the screen. In "live" measurement mode, the decimal point on the pH value will blink continuously. If the decimal point is not blinking, "A" must still be on the the screen of the pH meter. Press READ and hold until "A" disappears.
2. When the symbol ⌜ (not ⌜A) appears on the right hand side of the screen, pH of the solution is "stabled" and the value can be recorded. Note that in live measurement mode, pH value of the solution will change with time.



SET-UP FOR CONTINUOUS PH MEASUREMENT

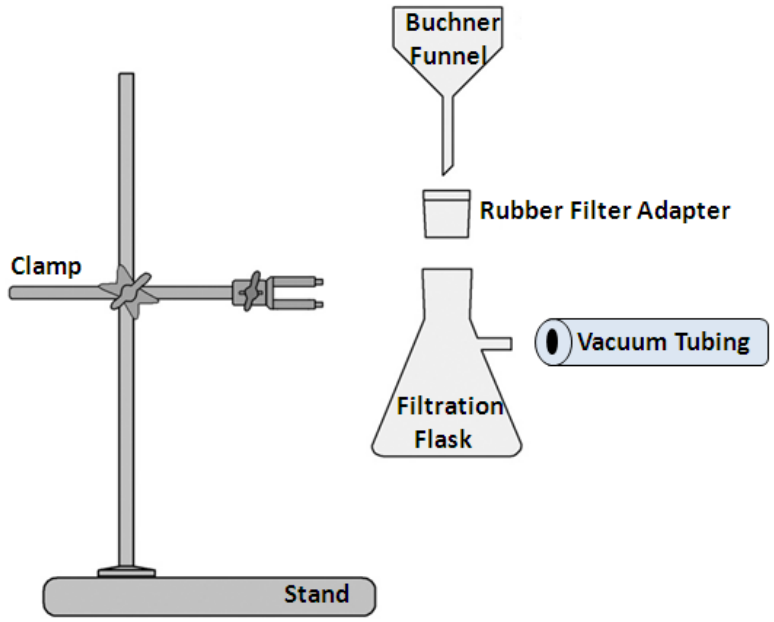
pH Meter Calibration Flowchart:



Appendix J: Filtration Apparatus

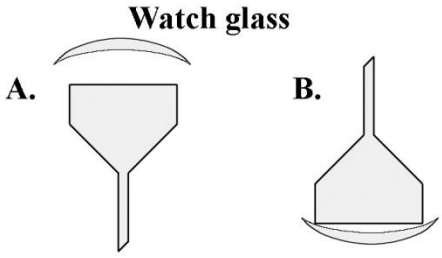
Scheme 1 describes how to properly set up a filtration apparatus.

1. Insert your Büchner funnel into a rubber filter adapter
2. Insert the rubber adapter in the opening of a Filtration Flask (an Erlenmeyer flask with a side arm).
3. Connect the side arm of the flask to one end of a piece of vacuum tubing.
4. Make sure that you secure your filtration flask to a stand using a clamp.
5. Don't forget to insert a filter paper into the Buchner funnel before pouring your solution!



Scheme 1. Filtration Apparatus

To collect your dry precipitate after the filtration step, put an inverted watch glass on top of the Büchner funnel (see Scheme 2). Holding both of them firmly together, invert the Büchner funnel as illustrated in Scheme 2. The precipitate and filter paper should fall in the watch glass.



Scheme 2. To collect your dry precipitate

Appendix K: Examples of Reference Formatting

The following examples show how to format references from various sources in American Chemical Society (ACS) style. Remember, ACS style is one of several different referencing styles that you may encounter when looking through scientific literature. You may use other styles if you wish, but you must be consistent (i.e. all references in the same list must be presented in the same style).

Reference type	**Format and example in ACS format**
Book with author(s)	Format: Author, A. A.; Author, B. B. Book Title (italics), Edition (if any); Publisher: Place of Publication, Year; Pagination. Example: Chang, R.; *Chemistry, 9th edition;* McGraw Hill: New York, 2007; p 251.
Book with editor(s)	Format: Editor, A. A., Editor, B. B., Editor, C. C., Eds. Book Title (italics); Series Information (if any, including series number); Publisher: Place of Publication, Year. Example: Lin, Q., Pearson, R. A., Hedrick, J. C., Eds. Polymers for Microelectronics and Nanoelectronics; ACS Symposium Series 874; American Chemical Society: Washington, DC, 2004.
Journal article	Format: Author, A. A; Author, B. B; Author, C. C. Title of Article. Journal Abbreviation (italics) [Online if online] Year (boldface), Volume (italics), Pagination. Example: J. S. Ritch, T. Chivers, D. J. Eisler, H. M. Tuononen, *Chem. Eur. J*. 2007, **13**, 4643-4653.
Website	Author, A. A. (if any). Title of Site. URL (accessed date), other identifying information. (No need to include URL of subscription sites, NOTE: if chemical(s) are being searched on that site reference must be made to the name used for the search). The Combined Chemical Dictionary database, web version 2004 (1); CRC Press: Boca Raton: FL (accessed July 16, 2004). n-Pentane.

The following references will be used often in Chemistry 209, but references of this type are not common in scientific literature. As they are not used commonly in scientific literature, it will be difficult to find examples of the style formatting needed. For the purposes of this course you can use the following formatting for personal communications and our course specific lab manual.

Reference type	**Example**
Personal Communication	Personal Communication; Ms. Sue Dent, University of Calgary, Calgary, Alberta, Canada, Chemistry 209, General Chemistry: Structure and Bonding, SPRING 2012 Lab Section B##.
Online Lab Manual	University of Calgary, Department of Chemistry, Chemistry 209, General Chemistry: Structure and Bonding, Online Lab Manual, SPRING 2012. Experiment #, pp. ##. See attached pages.