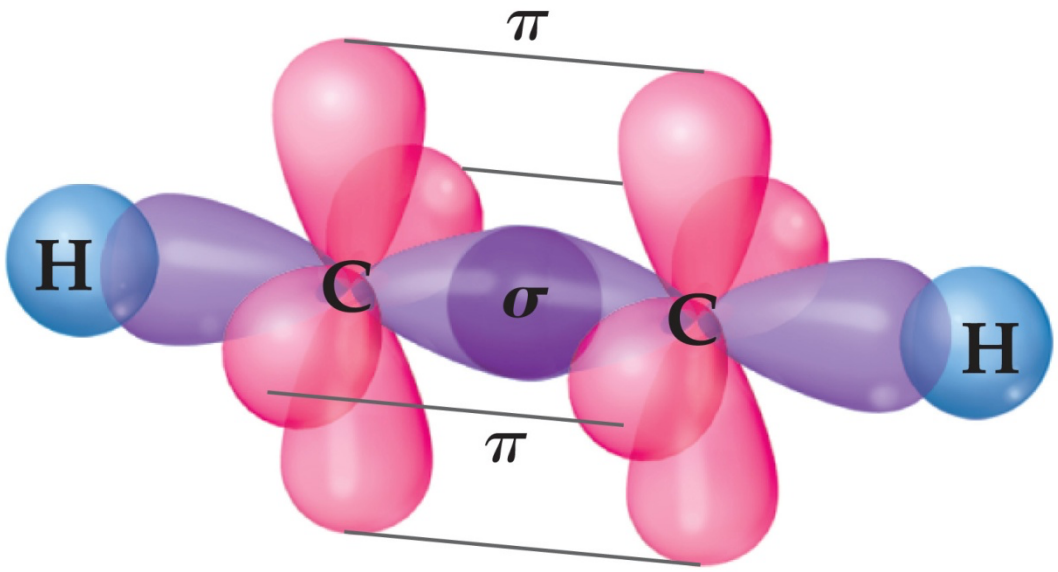


CHEMISTRY GUIDE

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CHEMISTRY GUIDE

GENERAL CHEMISTRY 202-NYA-05

SOLUTIONS CHEMISTRY 202-NYB-05

ORGANIC CHEMISTRY I 202-225-GA

ORGANIC CHEMISTRY II 202-295-GA
+ Comprehensive Assessment

Cégep de la Gaspésie et des Îles
CAMPUS DE GASPÉ

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Cégep de la Gaspésie et des Îles

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INFORMATION AND SAFETY

GENERAL INFORMATION

1. Workspaces will be assigned during the first laboratory period. Your space contains the vast majority of equipment that you will need for this course. It is not the policy of the chemistry department to demand a deposit for this equipment or to require that you pay for broken or missing equipment. However, it is to your advantage to work in a manner that reduces breakage. Breakages cost money. Money that will not be available for the purchase of other equipment or supplies to broaden your exposure to chemistry. As well, there is the inevitable blood to clean up off the floor. If something breaks, clean it up and dispose of it in the glass container, then ask the technician or the instructor for another one.
2. The assigned workspace will be yours for the semester. Wash up your equipment and rinse it with distilled water before you leave the lab. This will give it time to dry before the next period. **Do not leave it to next week!**
3. The proper functioning of the chemistry laboratory requires the cooperation of everyone in the lab.
    a. Do not waste chemicals. Take what you need, pouring chemicals directly into your container. Remember to label all chemicals and PUT THE TOP BACK ON THE REAGENT BOTTLE! Avoid the use of any instrument to transfer the reagent. This will reduce the chance of YOU contaminating the entire bottle. Likewise, do not return excess chemicals but dispose of them as directed.
    b. Clean up any spills immediately. Not to do so could be very dangerous and expensive.
    c. Conduct all operations that use or produce malodorous compounds in the fume hood.
    d. Do not abuse the balances. They are very expensive to purchase and repair. Never weigh hot objects–let them **COOL**. If it is too hot for you to pick up in your hands, then it is **TOO HOT TO WEIGH**.
    e. Do not dispose of insoluble or organic compounds in the sink. Use the appropriate receptacles.

SAFETY

The potential for injury and accident is very high in the chemistry lab. Yet each year, thousands of people work in chemistry labs without incident. Why? They have realized that it is much easier to prevent an accident than try to repair the consequences of one.

The prevention of accidents requires that you learn proper procedures, think about what you are doing, and pay strict attention to your work.

The rules listed below have evolved over the years to provide you with a guideline for reducing the possibility of serious accidents. It is essential you follow them. Insist that everyone does! It may be someone else's carelessness that involves you in an accident!

WORKING SAFELY IN THE LAB

The following suggestions are presented with the aim of eliminating the minor cuts, burns, etc. that occur to beginning students.

1. **Wash hands** upon entering and exiting the laboratory (**use hand sanitizer** frequently if you are experiencing cold symptoms, such as a runny nose, a sore throat, or you are coughing).
2. The insertion of glass tubing or thermometers into rubber stoppers causes a large number of cuts–some very serious. If the glass is fire polished and the correct size for the hole, you proceed as follows. Use a lubricant: H_2O, or better, glycerin. Hold the tube 3 cm from the stopper and insert with a twisting motion. Do not force it. If properly done, very little force is required.
3. Remember hot objects look very much like cold ones! Think before you touch it! If it's hot, use the appropriate tongs in your locker.
4. Keep your workspace neat. If you no longer need something, wash it and put it away.
5. If something falls, let it. Do not try to catch it. You will only make the situation worse.
6. Be careful heating liquids. If in a test tube, do not point it at anyone. If flammable, do not use a gas burner.
7. Concentrated acids are added to water.
8. Be especially careful with bases like NaOH. They can cause irreversible eye damage even in dilute concentration.
9. If in doubt, ask your instructor. It costs so little, while an accident can cost so much.

LAB SAFETY RULES

1. Approved eye protection must be worn at all times in the laboratory.
   a. Standard glasses are not sufficient protection. Wear goggles or safety glasses over them.
   b. Do not wear contact lens in the lab even while wearing goggles. Vapors can be trapped under the lens and cause irreversible eye damage.
2. A lab coat and closed shoes must be worn at all times. These will provide personal protection against chemical contamination, fire and spills to say nothing of your clothes.
3. Eating or drinking in the lab is strictly forbidden. You must also leave your water bottles outside the lab. Aside from the fire hazard, the possibility of contamination is too great. Never taste, smell or touch chemicals unless expressly directed to the contrary. It is also advisable not to bring food products (for consumption elsewhere) into the lab as they can absorb toxic vapors.
4. All injuries, burns, etc. must be reported to the instructor immediately.

PROPOSED SCHEDULE OF LABORATORY EXPERIMENTS

General Chemistry 202-NYA-05
&
Solutions Chemistry 202-NYB-05

- **Lab manual**: For instructions and procedures please refer to the documents provided by your professor and/or the following Website: http://gaspe.cgaspesie.qc.ca/pturkewitsch.

- Adjustments may occur as needed.

General Chemistry 202-NYA-05	
Experiment #	**Experiment Name**
1	Basic laboratory techniques and uncertainty
2	Mass and density measurements
3	Avogadro's number
4	Water of hydration
5	Conversion of a carbonate to a chloride
6	Stoichiometry of a reaction
7	Anion analysis
8	Atomic weight of magnesium
9	Molar mass of a volatile liquid
10	Ideality of oxygen
11	Atomic spectroscopy
12	Molecular models
	LAB TEST

Solutions Chemistry 202-NYB-05	
Experiment #	**Experiment Name**
1	Solubility tests and the extraction of peanut oil from peanuts
2	Molecular weight by freezing point depression
3	Determination of an equilibrium constant
4	Le Châtelier's principle
5	Introduction to titrations
6	Gram-equivalent weight of a solid acid
7	Determination of an unknown chloride
8	Determination of a solubility product constant
9	Acids, bases, and their salts
10	Hardness of water
11	Redox titration
12	Voltaic cells
13	Determination of a rate law
14	Titration

PROPOSED SCHEDULE OF LABORATORY EXPERIMENTS

Organic Chemistry I 202-225-GA
&
Organic Chemistry II and Comprehensive Assessment 202-295-GA

- For instructions and procedures please refer to the documents provided by the professor and/or the following website: http://gaspe.cgaspesie.qc.ca/pturkewitsch.

- Adjustments may occur as needed.

Organic Chemistry I 202-225-GA	
Experiment	**# weeks**
Introduction and laboratory safety	---
Synthesis of acetylsalicylic acid (aspirin) or acetaminophen	2
Recrystallization, solubility tests and decolorization	1 to 2
Melting points and boiling points	1
Thin-layer chromatography	1 to 2
Infrared spectroscopy and refractive indices	1
Extraction	3
Distillation	1 to 2

Organic Chemistry II & Comprehensive Assessment 202-295-GA		
Project #	**EXPERIMENT**	**# weeks**
I	Synthesis of *para*-aminobenzoic acid (PABA)	8
II	Synthesis of biodiesel – Comprehensive Assessment	5
Practical lab exam		3

LAB NOTEBOOK & PRELAB ASSIGNMENT

WHAT YOU NEED

✓ A separate **spiral bound notebook** (one where the pages cannot be removed). This will be your chemistry lab notebook.

WHAT TO DO BEFORE EACH LAB

To make maximum use of the time you spend in the lab, you must know what you are to do and what you are expected to observe. It is virtually impossible to perform the mechanical manipulations in the time allotted or to observe anything if you are always looking at the lab manual. Thus, it is your responsibility to read the material related to the laboratory, understand it and prepare your lab notebook for the start of each lab period. If there are procedures or calculations that you do not understand, see your instructor before the lab.

This prelab assignment will be marked before the lab actually begins. Please hand-in your prelab to Stéphane between 8 and 9 am on the MONDAY before the lab period on Wednesday.

PRELAB ASSIGNMENT

The prelab assignments will constitute 7% of your total mark for the class.

✓ The procedure may be found on the website http://web.cgaspesie.qc.ca/pturkewitsch/. Upon arriving at the laboratory, **you will be given a printed copy of the procedure to follow**. To prepare your prelab in your lab notebook you must:

- Use an ink pen (erasable ink is forbidden)
- Prepare data tables with sufficient space to record all the data you collect during the experiment for the number of trials required, as well as for all calculated and theoretical values.
- Include all calculations
- Answer any questions

- When asked for by the professor OR for the course *Organic Chemistry II & Comprehensive Assessment* (project-based course given during the winter semester): Present a **Table of Physical Properties** of all organic compounds and/or reactants used during the experiment. Look up needed data in the *Handbook of Chemistry and Physics*, or another reference book, for example *The Merck Index*. For General Chemistry and Solutions Chemistry courses prepare the **Table of Physical Properties** only when requested by your professor. An example is provided on the next page in the sample prelab assignment.

WHAT TO DO DURING EACH EXPERIMENT

✓ In your lab notebook, record, **in ink**:

- All procedural changes
- All data obtained during the experiment. If you make a mistake, draw a single line through it and write in the correct value. Remember this is not supposed to be a work of ART. Scrap pieces of paper will disappear!

On the next page is an example of a lab manual procedure and a sample prelab assignment.

SAMPLE LAB MANUAL PROCEDURE
&
PRELAB ASSIGNMENT

Sample lab manual procedure (such as that found on my website)

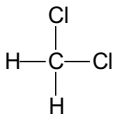
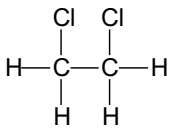
Density determination of an unknown liquid

Obtain a 100 mL Erlenmeyer flask and solid rubber stopper to fit. Carefully clean and dry the 100 mL Erlenmeyer flask. Weigh the flask and a rubber stopper to the nearest 0.01 g. Transfer 10.00 mL of the unknown liquid into the flask, using a 10-mL pipet. With the rubber stopper in place, weigh the flask, liquid and stopper to the nearest 0.01 g. Add another 10.00 mL of the unknown liquid, using the 10.00 mL pipet, to the 10.00 mL already in the flask. Replace the stopper and reweigh the flask. Continue in a like manner until a total of 50.00 mL has been added. Record the temperature of the unknown solution using a thermometer. Remember to use the thermometer clamp and a ring stand to securely hold the thermometer during the measurement. Clean and dry the Erlenmeyer flask and repeat the additions of 10.00 mL of unknown and weighing, until a total of 50.00 mL has been added. Repeat this procedure again to obtain a third set of data. Calculate the densities, the average density, the standard and relative deviations, and the percentage error.

Sample PRELAB assignment

Density Determination of an unknown liquid *1 September 2020*

Table 1. *Physical properties of possible unknown liquids*

Substance/Reagent	***MW (g/mol)***	***Density (g/mL)****	***mp (℃)***	***bp (℃)***	***Solubility***
dichloromethane 	*84.933*	*1.32662^{20}*	*-97.2*	*40*	*sl H_2O* *msc EtOH, eth* *s ctc*
1,2-dichloroethane 	*98.959*	*1.2454^{25}*	*-35.7*	*83.5*	*sl H_2O* *vs EtOH* *msc eth* *s ace, bz, chl*

**the values in superscript refer to the temperature at which the density values were measured*

*References: Provide reference following format in the **Reference Style Guide** section of this manual.*

Procedure

Unknown # (Identity): (To be noted on the day of the experiment)

Data Tables

Table 2. *Observations taken during the determination of the density of an unknown liquid*

Table 3.

	Trial 1			***Trial 2***			***Trial 3***		
Description	***Mass flask (g)***	***Mass unknown liquid (g)***	***Density (g/mL)***	***Mass flask (g)***	***Mass unknown liquid (g)***	***Density (g/mL)***	***Mass flask (g)***	***Mass unknown liquid (g)***	***Density (g/mL)***
Empty									
+ 10.00 mL									
+ 20.00 mL									
+ 30.00 mL									
+ 40.00 mL									
+ 50.00 mL									
Temperature of unknown liquid (°C)									
Average density per trial (g/mL)									
Average density of all 3 trials (g/mL)									
Standard deviation (relative standard deviation)									
Theoretical density value of dichloromethane (g/mL)				***1,32662^{20}***					
% error									

LAB REPORT

GENERAL INFORMATION

In this guide, the phrase, "**lab report**" has a broad meaning, and refers to any document completed after conducting experimental work and submitted to the professor for grading. The lab report may include any one of the following documents:

- **A formal laboratory report** – a lab report, including all, or almost all, of the sections of a lab report presented below (see *Sections of a laboratory report*, **page 13**). The formal lab report is written by the student(s).
- **A lab report sheet** – a short version of the lab report. This is a fill-in-the-blank type lab report, prepared by the professor and completed by the student(s).

The **lab report** is due one week after you finish the experimental work in the laboratory, unless otherwise indicated. The **lab report sheet** may be due at the end of a laboratory session or one week after the experimental work has been completed, unless otherwise indicated. Your professor will provide you with the details and the deadlines for each experiment.

It will be marked out 100 marks. The lab report or lab report sheet will constitute 65 marks, and the prelab, 35 marks, giving a total of 100 marks for each experiment.

It is essential that you understand the form and content of the lab report, whether it be a formal lab report or a lab report sheet. The general presentation format of a lab report is described below, as well as a brief description of, and comments on, the various sections of the report. **A sample lab report is also provided on pages 17-19.**

Always bear in mind that your report must demonstrate to the professor that you understand the material, and, as such, volume does not represent mastery.

PRESENTATION OF A LAB REPORT

- Your lab report is worth points. Make sure that the report is neat, organized, clear, and concise.
- **Use a quality of language that is professional**. Avoid the use of slang and the overuse of contractions.
- Make sure that you read the comments on your returned lab reports to avoid making the same mistakes again. Repeating mistakes will have a negative impact on your grade.
- **Proofread** your work!!

Paper

Use white paper of good quality with standard dimensions (**8.5 by 11 in.** or 22 by 28 cm). Use only one side of the paper.

Style

Printed on one side of the paper (**single-sided copy**). Only lab report sheets may be handwritten in INK (erasable ink is forbidden).

Do not print or write on both sides.

Margins

All margins must be set at a value between **2.0 to 2.54 cm**.

Font and font size

Times New Roman 12-point, unless otherwise specified. Other fonts may be used for tables, figures, images, diagrams, etc.

Spacing

Text must be written using **1.5-line spacing**. However, single line spacing may be used in the following cases:

- Titles longer than one line
- Table of contents
- Titles of tables, graphs, figures, etc.
- Tables, graphs, figures, etc.

Spacing (*continued*)

- Individual entries in the reference section may use single line spacing. However, a line must separate the individual entries from each other.
- Notes at the bottom of the page.
- Appendices and indices

Do not place a title or begin a new paragraph at the bottom of a page. Begin new sections and paragraphs on the following page.

Do not begin a table or figure at the bottom of a page. Place the full table, figure, image or graph on one page, when it is small enough to do so. When not small enough to be placed on one page, provide the column headings of the table or the title of the figure, image or graph on each page.

Pagination

Number all pages of a document, except the title page. The page number does not appear on the first page of the document.

Numbers

- Use the metric system of measurements unless otherwise specified. Abbreviations of units are used without a following period except at the end of a sentence.
- Numbers should be written as numerals when they are greater than ten or when they are associated with measurements; for example, 6 mm or 2 g, but *two* (2) explanations of *six* (6) factors.
- Do not leave your decimal places naked. For example, write 0.258 and not .258.
- Never start a sentence with numerals. Spell all numbers beginning sentences.

Significant figures and units

Always ensure that numbers have the correct units and the **correct number of significant figures**!!

Chemical formulas

Ensure that subscripts and superscripts are properly followed.

Brackets

There is no space between round ( ), square [ ], or brace { } brackets and the content they contain.

Grammatical person

- Avoid using the first person singular or plural, *I* or *we*, in writing. **Keep your writing impersonal, in the third person.**
- Do not use the first person, for example, *We weighed the frogs and placed them in a glass jar*. Use the third person, for example, *The frogs were weighed and placed in a glass jar*.

Verb tense

- Be consistent in the use of tense throughout a paragraph. Do not switch between past and present.
- Use the past tense when talking about the experiment, because the experiment is already finished. For example,
    - *The objective of the experiment **was**…*
- However, the report that you are writing, the theory and permanent equipment still exist. Therefore, these get the present tense. Some examples are:
    - *The purpose of this report **is**...*
    - *Dalton's atomic theory **is**...*
    - *The scanning electron microscope **produces** micrographs...*

Plural forms

- Be aware that the word *data* is plural while *datum* is singular. This affects the choice of a correct verb.
- The word *species* is used both as a singular and as a plural.

SECTIONS OF A LABORATORY REPORT

In your lab report, provide the sections requested by your professor, in the order presented below.

A sample lab report is provided on pages 17-19.

Use of words like "prove" and "true"

We, as scientists, test hypotheses to support, contradict or refute them. As such, we do not use the words "**prove**" or "**disprove**," and we avoid stating that a theory or hypothesis is true untrue, correct or incorrect. These terms reflect a degree of certainty that we, as scientists, do not possess. Remember that in our laboratory sessions we are testing a theory or hypothesis with a procedure that lasts only a few hours, includes only several trials, and uses, at best, only three (3) analytical techniques. This is not enough evidence, scientifically speaking, to claim to know the truth or the existence of a phenomenon. To evaluate your theory or hypothesis, use words like: **supported**, **indicated** and **suggest** when analyzing your results. Your results will "**support**," "**verify**," or "**confirm**" the theory or hypothesis, or they will "**negate**," "**refute**," or "**contradict**" it.

In addition, you must defend your claim concerning a theory or hypothesis by demonstrating to the readers that the statement made is based on facts, on verifiable data. The relationship between that data and the conclusions drawn from the data must be explicitly stated to show that the evidence warrants this claim.

Title, date and name

These need not be on a separate title page for weekly lab reports. However, for comprehensive assessment documents and project documents a title page must be presented.

Abstract

The purpose of the abstract is to give the reader a global view of the work. It is an abbreviated version of the work, written for people who may never read the complete version, and as such, should be written to stand on its own. It should contain sufficient information to allow the reader to determine the nature and scope of the information provided without having to read the entire work (lab report in this case).

The abstract is a concise and self-contained statement of the objectives of the experiment, the methods used to obtain the results, the results obtained, and the conclusions drawn from the experiment. The abstract is written last to be sure that it accurately reflects the content of the laboratory report. The professor will specify the length.

Abstracts are written in such a way as to NOT require figures, tables or images. Thus, figures, tables or images are not cited in the abstract. References are rarely cited. Only if absolutely necessary, equations and structures that appear in the laboratory report may be cited.

In the abstract you must:

- State the **overall objective**, briefly.
- Name or briefly describe the **basic methodology** used without going into excessive detail but be sure to indicate the **key techniques** used. Be brief but informative.
- Report the most important **results** obtained. State and compare calculated and theoretical values, identify your unknown, etc. Comment on the precision and the accuracy of the experiment in light of the standard and relative deviations, as well as the percentage error.
- Taking into consideration an experimental error, state how the experiment could be improved.
- State the major **conclusions**.

Objectives

State the purpose of the experiment. This is generally one or a few points describing what you are trying to show, to do or to find. General and specific objectives should be provided.

Introduction

The maximum length of this section is two (2) pages

This section includes a short discussion (summary) in your own words of the purpose and general theory related to the experiment. What is this experiment all about? Why did you conduct this experiment? Read the appropriate references, make notes of the important points, and then demonstrate your understanding of the relevant theory by presenting it in clear concise grammatically correct English. Pay particular attention to the techniques and instrumentation YOU used in the experiment. Include key concepts, definitions, important equations, and

assumptions. You need to show that YOU thoroughly understand the concepts. This need not be taken directly from the lab handouts or the lab manual.

It is a good idea to refer to other references as well.

Results

In general, the *Results* section tells the reader what happened during the experiment and what you observed, the techniques you used and the values you obtained.

Data, results and observations from the analysis of physical properties, chromatographic and spectroscopic data, as well as from other analytical methods will be organized in tables, figures and graphs according to the information provided below.

1. **Organize your data, results and observations in tables, figures and graphs**

   a. Present **raw data**, **calculated intermediate values** and **final values** in tables. Include the **average values**, the **standard deviation** and the **percentage error** if applicable. Observations and qualitative data may be presented in tables or a flow diagram. Present a **graph** of the data when applicable.

      Tables are numbered and contain a descriptive title at the top of the table. For an example, see Table 2 below. Make sure you include the correct units.

      Figures include graphs, images, diagrams, drawings, flow diagrams, etc. **They are only captioned – NOT titled**! The caption is situated at the bottom of the figure and includes a figure number and a title that describes the features you are trying to communicate to the reader. See Figure 1 on **page 22** as an example.

      Graphs are considered to be figures and are, therefore, captioned, not a titled! Label your axes with appropriate titles and units. Your graph may appear in your spreadsheet or on a separate page. Construct graphs in Microsoft Excel using the steps given below:

      1. Enter data for the x axis in column A
      2. Enter data for the y axis in column B
      3. Highlight the data in columns A and B
      4. From the **Insert** menu select **Chart**
      5. Select the chart type: **Scatter (XY) with only markers**
      6. Label axes and adjust other features of the chart to guidelines provided

   b. Provide **one sample calculation** (including arithmetic operations) from raw data to final answer underneath the table. Include the correct units with numbers. Pay attention to your significant figures (sigfigs) throughout your calculations!! The results must be written with the proper number of sigfigs. Remember to keep more digits throughout your calculations, and only round off to the correct number of sigfigs at the end of your calculations (rounding off too early might affect your final answer). See *Appendix 1* at the end of this manual.

   c. To estimate the precision and accuracy of your results calculate:
      - the standard deviation (see sample lab report on **page 18)** and
      - the percentage error (see sample lab report on **page 19**).

   d. Present unknown number and identity, when necessary.

Results (continued)

2. Treatment of data

a. Data obtained from the analysis of physical properties and other techniques that are NOT chromatographic or spectroscopic (e.g. titration, heat of combustion, qualitative chemical test):

- Provide the data, results and observations for three (3) trials, unless specified otherwise.

b. Chromatographic data:

- Provide a labeled representation of the developed plate
- Provide a table of masses, volumes and concentrations, as well as a table of migration distances and retention factor (R_f) values.

c. Spectroscopic data:

- Provide the experimental conditions: instrument (make and model), technique, sample holder, etc., as needed.
- Write a brief procedure – in point form.
- Provide a table of results such as the one presented below.

Table 2. Infrared spectral peak assignments for dichloromethane (unknown # 8). For each functional group, predicted frequencies (cm^{-1})* and experimental frequencies (standard and sample) obtained by total attenuated reflectance IR spectroscopy are presented.

Bond or functional Group	Predicted Frequency* (cm^{-1})	Experimental Frequency CH_2Cl_2 STANDARD (cm^{-1})	Experimental Frequency CH_2Cl_2 SAMPLE (cm^{-1})
Alkane C–H stretch	~ 2850-3000	2900	2930
Etc.	Add lines as needed		

* References: Values obtained from *Organic Chemistry* by Solomons and Fryhle. Provide references.

Discussion

The maximum length of this section is two (2) pages

Analysis of Results: State what you obtained and how you obtained it. Comment on the precision of your results. Comment on the accuracy of your results, by comparing your results to the literature or "accepted" value(s) (they can always be found, so search for them!!). Does it/do they agree with accepted theory? Why or why not? From a scientific point of view a "wrong" result (different from what you expected) is very interesting as soon as you try to understand why.

If you calculate a value using two different methods, make sure you compare the two answers and methods. What trends did you observe in the data? Remember each time the lab directs you to do something or observe something; there is a reason for it. Ask yourself WHY?

Analyze spectroscopic and chromatographic spectra if they form part of the experiment.

Answer any questions that appear in the procedure or any asked by your professor.

Analysis and Conclusion

Summarize your results and relate them to the purpose of the experiment.

- State what you were trying to do or to find (objectives)
- Reiteration of the results relating them to the objectives of the experiment
- Compare to theoretical and/or reported results
- Comment on precision and accuracy of the results
- Comment on the purity and structure of substance synthesized or extracted
- Comment on efficacy of the experiment. Was the technique you used a good one, could something be improved upon, could you use another technique that would improve the results?
- Provide possible sources of error and suggestions to improve those sources of error
- Provide recommendations regarding this experiment, suggestions to modify and/or improve the experiment, suggestions for future work (future directions). Invitation to broaden the debate.

Experimental Errors

A brief description of the major sources of **experimental error (random error)** is provided. **These are errors of the experiment NOT errors made by YOU, the experimenter.** In other words, these are not errors due to calibration problems (systematic errors, e.g. the balance was not calibrated properly), or YOUR manipulation limitations (human error, e.g. you misread an instrument or made a calculation error), but are limitations determined by the equipment, or the procedure. They are random or inherent errors mostly due to precision limitations of measuring devices. Try to determine how this error affects your results. That is, are your results over- or under-estimated?

References

You must always reference all the material you have used and referred to in order to gain knowledge and information. This includes all print and electronic sources, and as well experts in your field that you may have interviewed.

Please refer to the section, entitled *Reference Style Guide* (**page 23**), for further information about referencing.

Density Determination of an unknown liquid

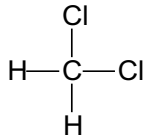
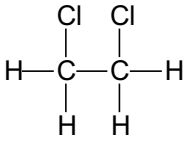
Petra Turkewitsch *1 September 2020*

OBJECTIVES

- *To determine the density, and thereby the identity, of an unknown liquid by weighing an Erlenmeyer flask before and after the addition of a certain volume of the unknown substance with a volumetric pipet.*

RESULTS

Unknown # 8: dichloromethane

Table 1. *Structures[1] and observations of the unknown liquids*	
Dichloromethane (unknown # 8) 	*Transparent colorless nonviscous liquid with a slight sweet aroma*
1,2-dichloroethane 	*Transparent colorless nonviscous liquid with a pleasant smell*
Note: Provide references following the style presented in the ***Reference Style Guide*** *section of this manual.*	

Density determination

Experimental conditions: ***In this space, list the experimental conditions, if applicable. See the Results section of the lab report on pages 14-16.***

Table 2. *Observations taken during the determination of the density of an unknown liquid*
In this table, note any observations taken during the experiment in point form.

Table 3. *Mass (g) of 100 mL Erlenmeyer flask upon adding various amounts of unknown liquid (# 8; dichloromethane), and comparison of the calculated density (g/mL) of this unknown with the theoretical value*[1]

	Trial 1			Trial 2			Trial 3		
Description	**Mass flask (g)**	**Mass unknown liquid (g)**	**Density (g/mL)**	**Mass flask (g)**	**Mass unknown liquid (g)**	**Density (g/mL)**	**Mass flask (g)**	**Mass unknown liquid (g)**	**Density (g/mL)**
Empty	*52.25*			*51.58*			*51.19*		
+ 10.00 mL	*65.30*	*13.05*	*1.305*	*64.28*	*12.70*	*1.270*	*66.01*	*14.82*	*1.482*
+ 20.00 mL	*78.54*	*13.24*	*1.324*	*79.02*	*14.74*	*1.474*	*78.19*	*12.18*	*1.218*
+ 30.00 mL	*90.56*	*12.02*	*1.202*	*91.02*	*12.00*	*1.200*	*90.10*	*11.91*	*1.191*
+ 40.00 mL	*106.75*	*16.19*	*1.619*	*10.39*	*15.37*	*1.537*	*107.20*	*17.10*	*1.710*
+ 50.00 mL	*118.03*	*11.28*	*1.128*	*118.21*	*11.82*	*1.182*	*117.68*	*10.48*	*1.048*
Temperature of unknown liquid (°C)			***23.0***			***23.0***			***23.0***
Average density per trial (g/mL)*			***1.316*^{23}**			***1.333*^{23}**			***1.330*^{23}**
Average density of all 3 trials (g/mL)*				***1.326*^{23}**					
Standard deviation (relative standard deviation)				***0.0091 (0,687 %)***					
Theoretical density value of dichloromethane (g/mL)*				***1.32662*^{20}**					
% error				***-0.047 %***					

**the values in superscript refer to the temperature at which the density values were measured*

***Sample Calculations**:*

Density

Density = mass / volume = (65.30 g - 52.25 g) / 10.00 mL = 1.305 g/mL

Standard deviation and relative standard deviation (%) calculations

$$mean\ or\ average = \bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$mean\ or\ average = \bar{x} = \frac{1.3156 + 1.3326 + 1.3298}{3} = 1.3260\frac{g}{mL} = 1.326\frac{g}{mL}(4\ significant\ figures)$$

$$standard\ deviation = \sigma_x = \sqrt{\frac{\sum_{i=1}^{n}|x_i - \bar{x}|^2}{n-1}}$$

Deviation from the mean	**Deviations from the mean squared**	**Sum of the squares of the deviations from the mean**	**Standard deviation (σ_x)**	**Relative standard deviation (%)**
$\|x_i - \bar{x}\|$	$\|x_i - \bar{x}\|^2$	$\sum_{i=1}^{n}\|x_i - \bar{x}\|^2$	$\sqrt{\frac{\sum_{i=1}^{n}\|x_i - \bar{x}\|^2}{n-1}}$	$\frac{\sigma}{\bar{x}} \times 100$
|1.3156 – 1.3260 |=	*0.0104 ^{2} = 0.00010816*	*0.00016616*	*0.009114823 = 0,0091 (4 places after the decimal = 2 significant figures)*	*0.68739239 = 0.687%*
|1.3326 – 1.3260 |=	*0.0066 ^{2} = 0.00004356*			
|1.3298 – 1.3260 |=	*0.0038 ^{2} = 0.00001444*			
			The standard deviation is always written to one more decimal place than the mean value	***Percentages may be expressed with 2 or 3 significant figures***

Percentage error calculation

$$\%\ error = \left(\frac{experimental\ value - theoretical\ value}{theoretical\ value}\right) \times 100$$

$$\%\ error = \left(\frac{1.3260 - 1.32662}{1.32662}\right) \times 100$$

$$\%\ error = -0.04673531\ \% = -0.047\ \%$$

NOTE: A negative % error indicates that your experimental value is lower than the theoretical value. Whereas, a positive % error indicates that your experimental value is higher than the theoretical value.

DISCUSSION

Properties of matter can be divided into intensive and extensive properties.[2] Intensive properties are those independent of sample size and extensive are dependent upon sample size. Density, pressure, and temperature are examples of the former, while volume and mass are examples of the latter. Density can be obtained from measurements of the extensive properties, mass and volume, as it is defined as mass per unit volume. Density, while now independent of sample size is, however, not independent of the other intensive properties, pressure and temperature. If the pressure on the sample increases, then so does the density. If the temperature increases, then in most cases the density will decrease. Thus, for most substances, densities increase from gas to liquid to solid. A very notable exception is water below 4°C.[2] Liquid water has a maximum density of 1.000 g/mL at 4°C.[1] However, as the temperature decreases, water's density also decreases. It is, thus, one of very few substances in which the solid has a lower density (0.9167 g/mL[1]) than the liquid (1.000 g/mL at 4°C).

In this experiment, the density of unknown # 8 (dichloromethane) was determined by weighing an Erlenmeyer flask before and after the addition of a certain volume of dichloromethane with a volumetric pipet. Three trials were conducted, yielding density values that ranged from 1.048 g/mL to 1.710 g/mL at 23.0°C and 757.4 mmHg. The average density values for each trial were determined to be: trial 1, 1.316; trail 2, 1.333; and trial 3, 1.330 g/mL. Thus the overall average density of dichloromethane of three (3) trials was 1.326 ± 0.0091 (0.687 %) g/mL.

Standard deviation is a measure of the precision of the results.[2] Thus, given that the value of the standard deviation obtained was small (0.0091 or 0.687 % g/mL), the results were precise. In view of the reproducibility with different sample size, density would appear to be an intensive property. The overall average density of dichloromethane agrees extremely well with the literature value for the density of dichloromethane (1.32662 g/mL[1]), therefore the results were also very accurate (% error = -0.047 %). The excellent agreement between the literature and experimental values for the density of dichloromethane also suggest that the unknown liquid was indeed dichloromethane. Further evidence that the unknown was an organic compound containing chlorine or bromine, is provided by the fact that it was a liquid at room temperature, it appeared to be quite volatile and it had a density above 1.00 g/mL.

CONCLUSION

The density of unknown # 8 (dichloromethane) was determined by successive additions of the unknown liquid to an Erlenmeyer flask, and subsequent weighing. After conducting three trials, the average density of dichloromethane was calculated to be 1.326± 0.0091 (0.687 %) g/mL at 23.0°C and 757.4 mmHg. The very small standard deviation (0.0091 or 0.687 %) indicates that the results were precise. The excellent accuracy (% error = -0.047 %) of the experimental value compared to the theoretical value (1.32662 g/mL) suggests that the unknown was dichloromethane. Dichloromethane is a transparent colorless liquid at 23.0°C and 757.4 mmHg with a slight sweet aroma. Given the excellent accuracy and precision of the results, dichloromethane seems to be very pure. This technique is, thus, an excellent one to determine the density of a liquid. However, the use of a pycnometer[3] would allow one to determine the density with even greater accuracy, that is, to five significant figures.

ERRORS

The main source of error may be the measurement of the volume of the unknown with the volumetric pipet. As volumetric pipets are calibrated for water, it is presumptuous to assume they will deliver the correct volume in this experiment. It would require the use of pycnometer or volumetric flask, at the temperature for which it was calibrated, to give an accurate volume.

REFERENCES (use the **National Library of Medicine** Style in zoterobib https://zbib.org)

1. *Haynes WM, Lide DR, editors. Physical constants of organic compounds. 94th ed., 2013–2014. Boca Raton, Fla.: CRC Press; 2013.*
2. *Brown TL, LeMay HE Jr, Bursten BE, Murphy CJ, Woodward PM, Stoltzfus MW. Chemistry: The central science. 13th edition. Boston: Pearson; 2015.*
3. *Pratten NA. The precise measurement of the density of small samples. Journal of Materials Science. 1981;17(7):1737.*

FLOW DIAGRAM

GENERAL INFORMATION

A flow diagram (scheme or chart) is a very visual representation of a procedure as it shows the different steps and/or manipulations as well as their correct order. Its purpose is, therefore, to help you understand how and why each step in a procedure is performed.

A flow diagram is often used in the following situations:

- **Synthesis**: To show the step-by-step synthesis of a substance. In a synthesis experiment, a flow diagram includes all important reactions and indicates where unwanted side products and excess or unreacted starting materials are separated from the desired product.
- **Purification**: To show how a substance is purified. Common techniques used to help isolate and purify an organic compound include extraction, recrystallization, gravity filtration, hot gravity filtration, vacuum filtration, distillation, and steam distillation. The organic chemist commonly uses two types of extractions: Solid-liquid extraction and liquid-liquid extraction. During a **solid-liquid extraction**, the solvent (liquid), in contact with the solid, dissolves the substances that are soluble in it. In this case, the flow diagram indicates the substances that are soluble in the solvent and those that remain in the solid (if known). The preparation of tea and coffee using hot water are examples of this type of extraction. A **liquid-liquid extraction** separates components of a mixture based on the preferential solubility of each component in the organic and the aqueous solvents. The flow diagram indicates compounds that are water soluble, and, thus, are found in the aqueous layer, as well as compounds found in the organic layer because of their solubility in organic solvents. In all cases, the flow diagram includes all important reactions, including acid-base reactions.
- **Analysis techniques**: To show how a substance is analyzed when performing a qualitative chemical test or when determining the solubility of a substance in different solvents (see **flow diagram 1** on the next page).

DRAWING A FLOW DIAGRAM

As you construct the flow diagram, ask yourself why each step is being performed and why each specific technique is being used. You must know the structure and physical properties of the reactants or compounds present, as well as of the products and/or by-products of all reactions.

During extractions, in order to help determine which components are present in the aqueous or organic layer, it may help to ask yourself, "**Have I converted a non-ionic substance to an ionic one?**" The ionic substances will be in the aqueous layer, the non-ionic ones in the organic layer.

<u>Important points about a flow diagram</u>

- ✓ In the boxes indicate all important:
  - Substances, solutions, phases (aqueous and organic) or mixtures AND their contents (ex. *crude caffeine crystals contain: caffeine and impurities such as chlorophyll*)
  - Results and/or conclusions (ex. *soluble, poor recrystallization solvent, etc.*)
- ✓ On the arrows – include the important manipulations and techniques
- ✓ Indicate:
  - Substances, solutions, phases or mixtures to discard
  - Separations of solids from liquids
  - Separations of aqueous phases from organic phases
- ✓ Include all important reactions

EXAMPLE OF A FLOW DIAGRAM

As an example, we will construct a flow diagram for testing the solubility of a solute in a solvent, an experiment that we will perform in Organic Chemistry I. The procedure is as follows:

> "The solubility of two solutes in three solvents will be determined. The solutes you will test are: Anthracene and acetaminophen. The three solvents you will use are: Hexane, acetone and water.
>
> To avoid cross contaminating your samples, be sure that your spatula and dropper are clean before moving on to another solute. Obtain six (6) test tubes and label them appropriately. To test the solubility of each solid, transfer about 10 mg into the labeled test tube. An amount that forms a symmetrical mound of about 4-5 mm in diameter on the end of a spatula is a good estimate of 10 mg. Add about 500 μL of room temperature solvent using a calibrated dropper and mix the contents. To mix the contents, either flick the end of the reaction tube with your finger or use a vortex. If any lumps remain after the contents have been mixed several times, use a glass-stirring rod to break them up. Observe. Note the degree of solubility of the solute (i.e. **soluble**, **insoluble** or **slightly soluble**).
>
> If the substance is readily soluble in the room temperature solvent, this solvent is not a good recrystallization solvent. Why? If the substance fails to completely dissolve in a given solvent at room temperature, add an additional 250 μL of solvent. You may add additional solvent to a total maximum volume of 1500 μL only. It is very important at the step to not add too much solvent, because adding too much solvent will hinder the crystallization of the solute when the mixture is heated and then is cooled. Note the degree of solubility of the solute (i.e. soluble, insoluble or slightly soluble) in the additional room temperature solvent. If the substance is now soluble in the additional room temperature solvent, this solvent is not a good recrystallization solvent. On the other hand, if the substance has still not completely dissolved in the solvent, its solubility must be tested in hot solvent."

Given this procedure the flow diagram below may be prepared (**flow diagram 1**).

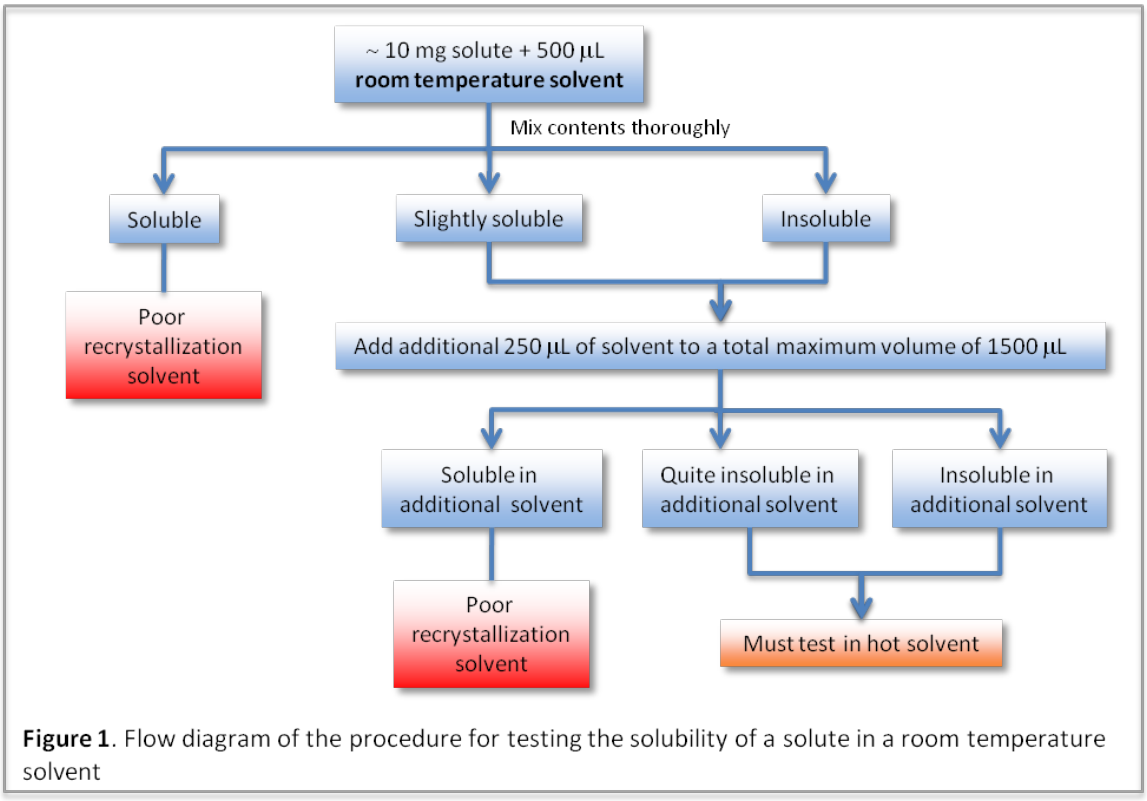


Figure 1. Flow diagram of the procedure for testing the solubility of a solute in a room temperature solvent

REFERENCE STYLE GUIDE

INTRODUCTION

Scientific writing, by nature, requires that we use the words and ideas of another. We are obliged to indicate exactly the source of our information and ideas. In other words, we must document or reference our sources. Thus, documenting or referencing is a standardized way of acknowledging the sources of information and ideas in scientific documents of the following type: lab reports, research papers, honors projects, theses and journal articles.

There is a very specific format that is used to reference, and this documentation style (reference style) depends on the discipline (e.g. science, human sciences, and arts). It is very important to be consistent and follow a specific style when you reference as well as verify the credibility of the sources of information used (see Verifying the credibility of sources).

WHY REFERENCE?

We reference for the following reasons:

- To acknowledge that certain information and ideas have already been presented by another person
- To identify the source of the information, so that the reader may locate your sources for further information, clarification or verification
- To identify the source of your inspirations
- To avoid plagiarism (see Appendix 2: *Plagiarism*, **p. 37**)
- To respect intellectual property rights (copyright, patent, trademark, etc.)

WHEN TO REFERENCE?

You must reference all information and ideas from an author, including but not limited to:

- Work consulted for inspiration or to gain knowledge of a particular topic
- Ideas, concepts, theories presented in the words of the author (quote) or in your own words (paraphrase)
- Charts, figures, images, graphs, etc.

REFERENCE STYLES

Each discipline has its own reference or documentation style. For example, the American Psychological Association (APA) and the Modern Language Association (MLA) reference styles are generally used in the humanities, behavioral and social sciences. In the sciences, almost every field of science has its own reference style. You must respect the reference style chosen by the professor of the specific course.

Chemistry courses will use the United States **National Library of Medicine** (NLM) Style Guide (Citing Medicine: The NLM Style Guide for Authors, Editors, and Publishers) that is popular in medicine and biomedical sciences. In this style, a superscripted number (author-number system or Vancouver system) is used in the text (in-text citation) to indicate the source, and these numbers refer to the reference list at the end of the document presented in the National Library of Medicine style (see *National Library of Medicine (NLM) Style* below).

VERIFYING THE CREDIBILITY OF SOURCES

- Each source must be evaluated to determine if it is reliable.
- To verify your sources, ask the following questions:
  1. Who is the author of the document/information? Who is publishing this information?
  2. What establishes the credibility of the author (his education, experience, position)?
  3. What establishes the credibility of the website and the information found therein?
  4. When was the information published? Is the source up to date?
  5. Does the author cite his sources?
  6. Could the source be biased? Does the source consider all viewpoints? For example, companies that sell goods/services may provide biased information to get people to buy their products.

National Library of Medicine (NLM) Style

This style of referencing uses in-text citations in the form of superscripted numbers, as well as a reference list at the end of the document.

- **In-text citations**
  - Place a superscripted number (author-number citation system or Vancouver system) within the document to indicate the source.
  - Start numbering at one (1) and progressively increases as new sources are cited. Each **in-text citation** number refers to its number in the bibliographic (reference) list presented at the end of the document. This list provides the complete bibliographic details of each source.

- **Reference list**
  - Use the online bibliographic generator called zoterobib (see the section below entitled *zoterobib*) to generate a numerical list of references that follow the bibliographic style of the **National Library of Medicine** (NLM).
  - Present this bibliographic list at the end of the document in a separate section entitled *References*. This list includes all the sources cited in the document, in the same order that they have been cited in the text.

In-text citations

General information

- An in-text citation is an acknowledgement in your document (text, tables, figures, etc.) of the source of information, ideas and inspirations that support your work.
- **In-text citations are in the form of Arabic numbers in superscript that correlate with a source of the same number in your reference list**.
- In-text citations are numbered in the order they first appear in the document starting at the number one (1), whether it be text, tables, figures, diagrams, pictures, etc. In-text citation numbering progressively increases as new sources are cited.
- The original number assigned to the reference is reused each time the reference is cited in the document, regardless of where it was originally used (i.e. regardless of its previous position in the text). In other words, once a number has been assigned to a reference, that number now belongs to this reference. Each time the reference is to be cited in the document it is assigned number is used regardless of its position in the text.

Format

- The following examples show the format used when one or more sources are cited at a given place in the document.

  - One source. Example[1]

    The textbook, *Chemistry: The Central Science,*[1] *provides* a chapter dealing with chemical equilibrium.

  - Two or more sources are cited at a given place in the text:

    - Use a comma (without a space) to separate two consecutive sources. Example[1,2]

      University research[5,6] has indicated that…

    - Use a hyphen to join the first and last numbers that are inclusive. Example[2-4]

      The main clinical and research interests of Dr Marilyn Campbell[5-7] are focused on...

- Use commas (without spaces) to separate non-inclusive numbers. Example [2-5,7,10]

> The fluorescence imaging of intracellular Ca^{2+} has been described extensively.[3,5-9,11]

- The placement of in-text citation numbers within the document should be carefully considered, because a particular reference may be relevant to only part of a sentence. The first figure[4] and the second figure[5]

> Fluorescent styrylpyridinium[2,3] and stilbene[5-7] molecules…

Punctuation

- Punctuation marks and spaces are very important.
- The following examples show the punctuation rules generally followed for numbered in-text citations. It is important to note that the punctuation style may vary according to the particular publisher.
  - Superscript number should be placed after full stops and commas.

> Chromatography is the separation of two or more compounds or ions caused by their molecular interactions with two phases – one stationary and one moving.[2]

  - Superscript number should be placed before colons and semicolons.

> Benzene has a vapor pressure of 760 torr at 80.1°C[4] if it is mixed with water,[7-9] the combined vapor pressure must equal 760 Torr at some temperature below 80.1°C.

  - If the superscript number is attached to an author's name or title of a book/database, then it is placed directly after the name.

> In 1949, Frank Dickey[7] was a student of Linus Pauling…

  - If the in-text citation is connected to a number (e.g. a year), place a space between the number and the in-text citation for clarity. Example 4 [7]

> The concept of molecular imprinting dates back to 1930 [5]….

REFERENCE LIST

- To generate the reference list, use the online bibliographic generator called zoterobib. See the section below entitled *zoterobib* for instructions.
- This list contains the full bibliographic details of all the sources (e.g. book, journal article, internet site) cited in the document.
- The reference list is presented at the end of the document in a separate *References* section with the entries listed numerically and in the same order that they have been cited in the document.

zoterobib – online bibliographic generator (https://zbib.org)

Introduction

- Use the online tool called **zoterobib** (https://zbib.org) to generate a reference list.
- Note: In general, using **zoterobib** I found it difficult to find sources using the title and author of the document. You will find some easier methods to find sources described in the sections below:
  - Books– print and online
  - Part of a book – print and online
  - Periodicals (journals, magazines) and newspapers – print and online
  - Web pages
  - Videos

To setup zoterobib

1. Go to **zoterobib** (https://zbib.org).
2. In the **Cite** field, enter an ISBN number of the book, a URL link of the internet site, a DOI number of the article or a title.

   For example:

   - *Haynes, Handbook of Chemistry and Physics, 94th edition*
   - *Graham Solomons Organic Chemistry*
   - *Structures nomenclature réactions chimie organique*
3. Click **Cite**.
4. In the list that appears, select the citation that corresponds to the source you are looking for.
5. The source now appears in the bibliography section.
6. In the dark blue bar under the bibliography title, click the down arrow (∨) and select **9700+ other styles available**.
7. In the search field, enter **National Library of Medicine** and select it from the list.
8. Click **Add**.
9. In the bibliographic list further down on the page, your source now appears in the ***National Library of Medicine*** format.
10. The following pages present a detailed description of how to use **zoterobib** to cite:
    - Books– print and online
    - Part of a book – print and online
    - Periodicals (journals, magazines) and newspapers – print and online
    - Web pages
    - Videos
11. You may create your full bibliographic list using **zoterobib**.
12. Once complete, go to the bottom of the page. Under **Export** click **Copy to clipboard** and paste the list into your document.

BOOK – PRINT AND ONLINE

1. Find the 13-digit ISBN number of the book. To find the ISBN number, search through the first few pages of the book or find the book on Amazon or the publishers home page. The ISBN number will be listed on the web page.
2. Enter the book ISBN in the **Cite** field on zoterobib.
    - Note: For online books, you may try to copy the URL and paste it into the **Cite** field. However, if this does not give you the correct book, you will have to use the book ISBN or enter the bibliographic information manually.
3. Click **Cite**.
4. The book appears in the shaded blue area below the **Cite** field.
5. Make sure that the reference contains to the information in the list below. If not, you will have to find the information and enter it manually. It is important to note that a credible reference must have this information (see *Verifying the credibility of sources*).
    - Title
    - Authors
    - Edition (if necessary)
    - Place of publication
    - Publisher
    - Date
    - URL (for online books)
    - Accessed (for online books)
6. To add or change any information, click on **Edit**. A new window opens with many fields, some of which are already populated.
7. When finished, click **Done**.
8. The main page reappears. In the bibliographic list further down on the page, your source now appears in the ***National Library of Medicine*** format.
9. You may continue to build the bibliographic library in zoterobib.
10. Once complete, under **Export** (further down on the page), click **Copy to clipboard** and paste the list into your document.

Examples

Print Books

Solomons TWG, Fryhle CB, Snyder SA. Organic chemistry. 12th Edition. Hoboken, NJ: Wiley; 2016.

Haynes WM, Lide DR, editors. CRC handbook of chemistry and physics: a ready-reference book of chemical and physical data. 94th ed., 2013–2014. Boca Raton, Fla.: CRC Press; 2013.

Online books

Sarin A. Biodiesel: Production and Properties [Internet]. Royal Society of Chemistry; 2012. 281 p. Available from: https://books.google.ca/books?id=72klFb2goSUC&pg=PA63&source=gbs_selected_pages&cad=2#v=onepage&q&f=false

PART OF A BOOK – PRINT AND ONLINE

1. Find the 13-digit ISBN number of the book. To find the ISBN number, search through the first few pages of the book or find the book on Amazon or the publishers home page. The ISBN number will be listed on the web page.
2. Enter the book ISBN in the **Cite** field on zoterobib.

   Note: For online books, you may try to copy the URL and paste it into the **Cite** field. However, if this does not give you the correct book, you will have to use the book ISBN or enter the bibliographic information manually.
3. Click **Cite**.
4. The book appears in the shaded blue area below the **Cite** field.
5. Click on **Edit**. A new window opens with many fields, some of which are already populated.
6. In the **Item Type** field, select **Book section**.
7. Copy the name of the book from the **Title** field and paste it into the **Book title** field below the authors.
8. Now, in the **Title** field you may enter the section of the book you wish to cite (e.g. the chapter number and title: *Chapter 23 Lipids*).
9. Make sure that the reference contains the information in the list below. If not, you will have to find the information and enter it manually. It is important to note that a credible reference must have this information (see *Verifying the credibility of sources*).
   - Title
   - Authors
   - Edition (if necessary)
   - Place of publication
   - Publisher
   - Date
   - URL (for online books)
   - Accessed (for online books)
10. When finished, click **Done**.
11. The main page reappears. In the bibliographic list further down on the page, your source now appears in the ***National Library of Medicine*** format.
12. You may continue to build the bibliographic library in zoterobib.
13. Once complete, under **Export** (further down on the page), click **Copy to clipboard** and paste the list into your document.

Examples

Section of a print book

Solomons TWG, Fryhle CB, Snyder SA. Chapter 23 Lipids. In: Organic Chemistry. [12th edition], global edition. Hoboken, New Jersey: John Wiley & Sons, Inc; 2016.

Haynes WM, Lide DR, editors. Physical constants of organic compounds. In: CRC handbook of chemistry and physics: a ready-reference book of chemical and physical data. 94. ed., 2013–2014. Boca Raton, Fla.: CRC Press; 2013.

Section of an online book

Sarin A. Chapter 3 Biodiesel properties and specifications. In: Biodiesel: Production and Properties [Internet]. Royal Society of Chemistry; 2012. Available from: https://books.google.ca/books?id=72klFb2goSUC&pg=PA63&source=gbs_selected_pages&cad=2#v=onepage&q&f=false

PERIODICALS (JOURNALS, MAGAZINES) AND NEWSPAPERS – PRINT AND ONLINE

Journal article (e.g. Journal of Chemical Education)

1. Find the DOI (digital object identifier) number of the journal article in:
   - Article itself
   - Google scholar (https://scholar.google.com)
   - Journal of Chemical Education (http://www.cegepgim.ca/biblio/gaspe)
2. Enter the DOI number in the **Cite** field on zoterobib.
3. Click **Cite**.
4. The periodical appears in the shaded blue area below the **Cite** field.
5. Click on **Edit**. A new window opens with many fields, some of which are already populated.
6. In the **Item Type** field, select the appropriate item according to the type of periodical:
   - For a journal article, select **Journal article**
   - For a newspaper article, select **Newspaper article**
   - For a magazine article, select **Magazine article**
7. Make sure that the reference contains the information in the list below according to article type. If not, you will have to find the information and enter it manually. It is important to note that a credible reference must have this information (see *Verifying the credibility of sources*).

Journal article

- Title
- Authors
- Publication – Journal name
- Volume
- Pages
- Date

  Note: Online articles do not require the URL

Newspaper article

- Title
- Authors
- Publication – Newspaper name
- Date
- URL (for online sources)
- Accessed

Magazine article

- Title
- Authors
- Publication – Magazine name
- Date
- URL (for online sources)
- Accessed

8. When finished, click **Done**.
9. The main page reappears. In the bibliographic list further down on the page, your source now appears in the ***National Library of Medicine*** format.
10. You may continue to build the bibliographic library in zoterobib.
11. Once complete, under **Export** (further down on the page), click **Copy to clipboard** and paste the list into your document.

Newspaper or magazine article

1. Copy the URL of the newspaper or magazine.
2. Paste the URL into the **Cite** field on zoterobib.

Examples

Journal article

Clarke NR, Casey JP, Brown ED, Oneyma E, Donaghy KJ. Preparation and Viscosity of Biodiesel from New and Used Vegetable Oil. An Inquiry-Based Environmental Chemistry Laboratory. J Chem Educ. 2006 Feb;83(2):257.

Newspaper article

Authier P. Quebec will move medical staff to Montreal's coronavirus battlefront. Montreal Gazette [Internet]. [cited 2020 Apr 20]; Available from: https://montrealgazette.com/news/quebec/hospitals-put-on-slowdown-doctors-redirected-to-covid-19-front-lines-chslds

Magazine article

Treble P. Coronavirus in Canada: These charts show how our fight to "flatten the curve" is going - Macleans.ca. Maclean's [Internet]. 2020 [cited 2020 Apr 20]; Available from: https://www.macleans.ca/society/health/coronavirus-in-canada-these-charts-show-how-our-fight-to-flatten-the-curve-is-going/

WEB PAGES

1. Copy the URL of the web page and paste it into the **Cite** field on zoterobib.
2. Click **Cite**.
3. The web page appears in the shaded blue area below the **Cite** field.
4. Click on **Edit**. A new window opens with many fields, some of which are already populated.
5. Make sure that the reference contains the information in the list below. If not, you will have to find the information and enter it manually. It is important to note that a credible reference must have this information (see *Verifying the credibility of sources*).
    - Title (of web page)
    - Authors
    - Website title
    - Publisher
    - Date
    - URL
    - Accessed
6. When finished, click **Done**.
7. The main page reappears. In the bibliographic list further down on the page, your source now appears in the ***National Library of Medicine*** format.
8. You may continue to build the bibliographic library in zoterobib.
9. Once complete, under **Export** (further down on the page), click **Copy to clipboard** and paste the list into your document.

Examples

Website: Collection of web pages that are linked together. One website may have many web pages, e.g. Health Canada.

Corporation for Digital Scholarship. ZoteroBib [Internet]. ZoteroBib. Corporation for Digital Scholarship; 2020 [cited 2020 Apr 21]. Available from: https://zbib.org/

Web page: A specific page of a website

National Biodiesel Education Program. Triglyceride Molecular Weight Calculator [Internet]. Biodiesel Education Program. University of Idaho; 2019 [cited 2020 Apr 17]. Available from: http://biodieseleducation.org/index.html

VIDEOS

1. Copy the URL of the video and paste it into the **Cite** field on zoterobib.
2. Click **Cite**.
3. The video appears in the shaded blue area below the **Cite** field.
4. Click on **Edit**. A new window opens with many fields, some of which are already populated.
5. In the **Item Type** field, select **Video Recording**.
6. Make sure that the reference contains to the information in the list below. If not, you will have to find the information and enter it manually. It is important to note that a credible reference must have this information (see *Verifying the credibility of sources*).
    - Title (of the video)
    - Directors (authors)
    - Studio (YouTube or other)
    - Date
    - URL
    - Accessed
7. When finished, click **Done**.
12. The main page reappears. In the bibliographic list further down on the page, your source now appears in the ***National Library of Medicine*** format.
13. You may continue to build the bibliographic library in zoterobib.
14. Once complete, under **Export** (further down on the page), click **Copy to clipboard** and paste the list into your document.

Examples

Cormier K. Filtration sous vide [Internet]. YouTube; 2014 [cited 2020 Apr 21]. Available from: https://www.youtube.com/watch?v=1cFcCIuCbL8

ChemSurvival. Introduction to Recrystallization [Internet]. YouTube. 2012 [cited 2020 Apr 21]. Available from: https://www.youtube.com/watch?v=htTvL4JhscM&list=PLAhRiX8pHhMLvkECEEmqF8jCbmoNYq7v_&index=2

APPENDIX 1: LABORATORY MEASUREMENT AND UNCERTAINTY

Measurement by its very nature has limitations, which must be appreciated by anyone making them or using them. Any quantity capable of existing in a continuous manner can never be measured exactly.

Some uncertainty is associated with any measurement. To be completely specific on any item of data, one must estimate the accuracy of measurement. The general rule of thumb is that the uncertainty in any measurement is 1/2 the smallest graduation. For example, if the length of some object is between 25.5 cm and 25.6 cm, it would be reported as 25.55 ± 0.05 cm. Normally you can be fairly certain the actual value lies in this range.

When measured quantities are used to calculate another quantity, uncertainty in the measurements introduces uncertainty in the calculated result. When the uncertainty in each measured quantity has been estimated, the uncertainty in the result can be obtained by the following rules. The point to remember is that your final answer must reflect the uncertainty in your measurements.

1. The uncertainty in a sum or difference is the sum of the uncertainty in the individual terms. For example:

Weight of flask A	16.7321	± 0.0005 g
Weight of flask B	16.84	± 0.05 g
Total	33.5721	± 0.0505 g

Since the uncertainty is in the second decimal, round off the total to 33.57 ± 0.05 g. Notice the datum with the fewer number of digits after the decimal determines the uncertainty. Normally, unless you use the wrong balance weighing will not be the determining factor for the uncertainty in any experiment.

2. When the measurements are multiplied or divided to obtain the desired quantity, the percentage uncertainty, not the uncertainty, is added.

EXAMPLE

Weight of block = 5.324 ± 0.005g

% uncertainty = (0.005 / 5.324)*100 = 0.09391%

Volume of block = 7.1 ± 0.5 mL

% uncertainty = (0.5 / 7.1)*100 = 7.0%

Hence the density = 5.324 / 7.1 = 0.7499 g/mL = 0.75 g/mL (2 sigfigs)

% uncertainty = 7.0% + 0.09391% = 7.1 %

Therefore, the uncertainty in density is (0.071) x 0.7499 g/mL = 0.053 g/mL. Again, we write the value to reflect the uncertainty, i.e. density = 0.75 ± 0.05 g/mL. Notice it is the volume that determines the uncertainty in the density (i.e. the value with the largest % uncertainty determines the % uncertainty in the calculated value).

SIGNIFICANT FIGURES

Rather than having to calculate uncertainty or % uncertainty for each measured quantity and then sum them as above, it is common to use the concept of significant figures to ensure that a calculated value is shown with the correct degree of uncertainty. In most cases significant figures will give the correct degree of uncertainty.

The number of significant figures is defined as the number of digits not used for placing the decimal marker and ones we know something about. For example:

Number	Significant Figures
124.3	4
1.24	3
1.2	2
0.12	2
0.012	2
0.0120	3 (better to write as 1.20×10^{-2} then there is no doubt)

As the number of significant figures increases, the % uncertainty decreases.

EXAMPLE

% uncertainty in 124.3 = (0.5 / 124.3)*100 = 4×10^{-1} %

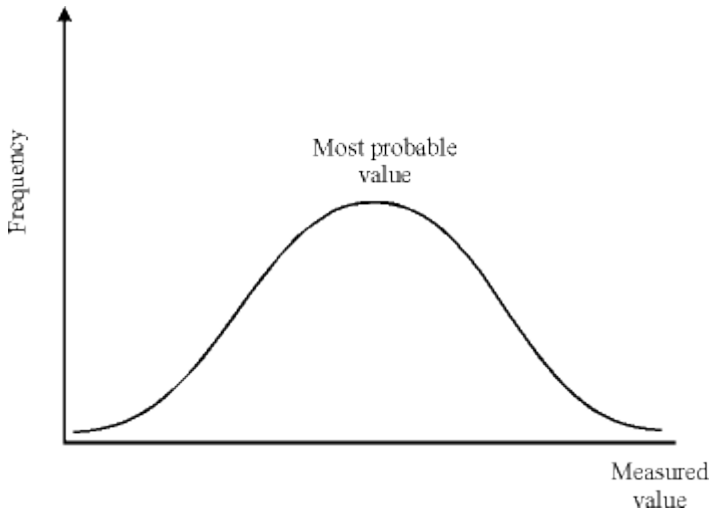
% uncertainty in 1.24 = (0.05 / 1.24)*100 = 4%

% uncertainty in 31 = (5 / 31)*100 = 1.6×10^{1} %

To a first approximation, two numbers with the same number of significant figures have the same uncertainty. As was shown previously, the datum with the largest percentage uncertainty determines the uncertainty in the calculated quantity. **Thus, the rule of thumb is that the calculated number has the same number of significant figures as the datum with the smallest number of significant figures.** However, it is necessary to be careful with numbers like 9.8 and 10.1. They have different numbers of significant figures but the same % uncertainty so this rule of thumb must be used judiciously. In fact, at this stage of your chemistry career it is useful to observe that three (3) significant figures is the norm for most laboratory experiments and problems except in titrations where you will find four (4). Any ideas why?

CENTRAL TENDENCY

Generally, you will find that all measurements in scientific work are taken a number of times. The rational for this repetition has been formalized by a branch of mathematics called statistics. Most sets of measurements will approximate a normal or Gaussian distribution if the errors are random in nature. The arithmetic mean (average) of a finite set of measurements is the best approximation of the most probable value (the peak of the curve)



The validity of the approximation depends upon the precision (or mutual agreement) of the measurements. If there is close agreement between the measurements, then you can have confidence that the average is the best that can be obtained from the experimental procedure.

ACCURACY

Accuracy refers to the agreement between measurement and the "true" or accepted value based upon the best experimental technique. People commonly assume that precise results are also accurate results. While precise results are required for accurate ones, there is no guarantee they will be accurate. A systematic error can make the most precise results worthless. Thus, it is important to design out systematic errors in experimental procedures.

APPENDIX 2: PLAGIARISM

This appendix includes a document describing plagiarism that was published by the *University of Ottawa*. Students must read and become completely familiar with this document. The document begins on the following page.

Beware
of plagiarism*!

it's easy
it's tempting

...but it can be very costly**!

Last year, more than 100 University of Ottawa students who were accused of plagiarism received various sanctions, including expulsion from the University.

uOttawa

L'Université canadienne
Canada's university

* *To plagiarize is to borrow someone else's words or ideas without mentioning his/her name and/or without using quotation marks ("...").*

** *Consult the Academic Integrity Website*
web5.uottawa.ca/mcs-smc/academicintegrity/home.php

www.uOttawa.ca/plagiarism.pdf

August 2009

AVOIDING PLAGIARISM

PLAGIARISM is taking another person's words, ideas or statistics and passing them off as your own. The complete or partial translation of a text written by someone else also constitutes plagiarism if you do not acknowledge your source.

Since we cannot always be original it is entirely acceptable to present another person's ideas in your work. However, it must be done properly to avoid plagiarism.

PRINCIPLES AND RULES

- When borrowing another person's words, use quotation marks and include complete reference (author's name, date, pages).
- Internet sources must also be acknowledged.
- When borrowing another person's ideas, acknowledge their origin.
- Do not paraphrase another writer's words and pass them off as your own.

TWO BASIC RULES:

- If you use someone else's words, data, etc., use quotation marks and give a complete reference.
- If you borrow someone else's ideas, give a complete reference.

EXAMPLES

Should you want to use this source:

Over time technology has been instrumental in increasing industrial and agricultural production, improving transportation and communications, advancing human health care and overall improving many aspects of human life. However, much of its success is based on the availability of land, water, energy, and biological resources of the earth.*

* David PIMENTAL (1998) "Population Growth and the Environment: Planetary Stewardship", Electronic Green Journal: Vol. 1: No. 9, Article 10. http://repositories.cdlib.org/uclalib/egj/vol1/iss9/art10

WHAT IS UNACCEPTABLE

You wrote*:	This is unacceptable because:
Research has shown that **technology has been instrumental in increasing industrial and agricultural production, improving transportation and communications, advancing human health care and overall improving many aspects of human life. However, much of its success is based on the availability of land, water, energy, and biological resources of the earth.**	• Other than the first four words, the text has been copied word for word from the original document without any quotation marks that would indicate that the passage is a quote. • The source you are using is not cited.
Research has shown that the advancement of **technology has been instrumental in increasing industrial and agricultural production, improving transportation and communications, health care and overall many aspects of human life. (Pimental, 1998)**	• Even though you mention your source, you use many of the author's words without quotation marks.
Research has shown that the advancement of science has been beneficial to the areas of agricultural and industrial production and communication and transportation fields. Furthermore, science has greatly improved health care and is the prime factor in a higher standard of life for many people.	• Though most of the words have been changed, the sentence structure has remained the same. • This is paraphrasing without indicating the original source.

* The words in bold are used in the source text.

WHAT IS **ACCEPTABLE**

You wrote:	This is acceptable because:
In his article on the effects of population growth on the environment, Pimental argues that "technology has been instrumental in increasing industrial and agricultural production, improving transportation and communications, advancing human health care and overall improving many aspects of human life. However, much of its success is based on the availability of land, water, energy, and biological resources of the earth" (1998).	• The author has been acknowledged, and the quoting technique which has been used is adequate since this is an Internet source. However, when you quote a printed source (book, journal, etc.), be sure to include the page numbers.
According to Pimental, "technology has been instrumental in increasing industrial and agricultural production, improving transportation and communications, advancing human health care and overall improving many aspects of human life" (1998). He cautions, however, that technological progress is dependent on natural resources.	• You have properly quoted and paraphrased the author.
According to Pimental (1998), technology has greatly improved our standard of living. He cautions, however, that technological progress is dependent on natural resources.	• This is the proper way to paraphrase and the author's ideas have been credited.

Referencing Styles

- *Writing and Style Guide for University Papers and Assignments,*
  www.sciencessociales.uOttawa.ca/guide-en.asp
- *Academic Writing Help Centre Writing Kit, tools prepared by SASS*
  www.sass.uottawa.ca/writing/kit/
- *Referencing Guides*
  - APA References (American Psychological Association)
    www.sass.uottawa.ca/writing/kit/reference-apa.php
  - CM References (Chicago Manual)
    www.sass.uottawa.ca/writing/kit/reference-cm.php
  - MLA References (Modern Language Association)
    www.sass.uottawa.ca/writing/kit/reference-mla.php
- *How to avoid plagiarism*
  www.socialsciences.uottawa.ca/eng/documents/Howtoavoidplagiarism.pdf
- *History Essay Guide,* prepared by the Department of History. Available from the secretariat of the Department.
  www.history.uottawa.ca/PDF/HISTORY_ESSAY_GUIDE.pdf
- *Style Sheet*. Working with Sources. Introduction to Research in English Literature, prepared by the Departement of English. For sale at the Campus Bookstore
- *Pathfinders*
  www.biblio.uottawa.ca/content-page.php?c=src-suj&g=en&s=biblio&spec=54
- *"Says who?" Integrity in Writing: Avoiding Plagiarism*
  www.sass.uottawa.ca/writing/kit/plagiarism.pdf