 CHEMICAL ENGINEERING LABORATORY  
 CHEG 237/239  

Preparation of Laboratory Reports

Introduction

The purpose of any report is to convey information to the reader in such a way as to convince him or her to accept your conclusions and recommendations. Be clear, concise, and factual. Have your conclusions and recommendations in mind before you begin writing and focus your report towards substantiating these ideas. Make a detailed outline before beginning any writing. The mere taking and reporting of data are insufficient; intelligent interpretation must be included.

The exact form of a technical report will vary depending upon the kind and amount of material to be treated, unique organizational practice, and the individual tastes of the manager for whom the report is intended. Whatever the form may be, it must be borne in mind that the primary purpose of the report is to convey information in the shortest possible time, clearly and completely.

I. Report Format

The following report form is a very general one and is recommended for the reports in this course:

**Introductory material**

1. Title page
2. Abstract or summary
3. Table of Contents

**Body of the report**

4. Introduction
5. Theory (if needed and not included in the introduction)
6. Apparatus and materials
7. Procedure (may be included with apparatus)
8. Results, including key figures and tasks with final, polished data
9. Discussion of the results (may be combined with results)
10. Conclusions
11. Recommendations (optional)
12. Nomenclature
13. Literature cited, References, Bibliography or Footnotes
Appendices

14. Original data
15. Sample Calculations
16. Table of intermediate derived data of calculated values which are too long to include in the text.
17. Long derivations of equations (if needed)
18. Calibration curves, and other graphs if too numerous and repetitive to include in the body of the report.
19. Supplementary exposition (if needed)
20. Supplementary bibliography (if needed)

In some cases, deviation from this recommended form may be desirable, but those desiring to modify the organization should discuss changes with the instructor before writing the report.

II. Detailed Description of Major Report

Detailed instructions in the sections which follow state the requirement for each section of the report.

1. Title Page

This should be a separate page and should include: author’s names, course number, topic number and title, and date of presentation. Also show the number of hours spent (a) in preparation, (b) in laboratory, (c) in calculation and (d) in write-up. The sum of these four numbers should equal the total time spent on the experiments and the report. These times are for information in planning future experiments and will not affect any grade in this course.

2. Abstract or Summary

The abstract should be a concise overview of the report directed at a person who has had little contact with the work, and should enable this person to decide without further investigation on the relevance of your report to his/her needs. The abstract should provide the reader with a brief understanding of the problem, the conditions studied, the important results, and their significance. The abstract should only contain statements supported by the report and may repeat some statements in the report.

The terms summary and abstract are sometimes used interchangeably. Often, however, a summary is somewhat longer and more quantitative, especially in regard to results and possible errors. In this course, neither the summary nor abstract should be more than one typewritten page, double-spaced, in length. Two hundred words is a typical Abstract length.
In preparing an abstract, first note the results and consider how they satisfy the objective of the experiment. Write the significant results with this relation in mind. Then being concise and specific, put down what was done to arrive at the results. Do not include how the results were achieved in the abstract. Next identify the facility (equipment or setup) used and finally reverse the order. Do not reference any report item, figure, table, equation, etc., in the abstract. The abstract should stand on its own. Examples of abstracts may be found in the “ACS Style Guide”.

3. Introduction

This section provides a brief description of the problem and its importance, plus a connecting entrance into the material in the body of the report. Also preview the theoretical methods to be used or tested and provide relevant equations. This connection is often in terms of a very brief review of earlier attempts to investigate the problem. (If extensive theory is needed, or if a modification has been incorporated, use a separate section.) Do not give conclusions or recommendations in this section. The last statement in the introduction is often a concise statement of your objectives in this experiment.

4. Experimental

Briefly describe the experimental apparatus and procedures. Include a schematic drawing of the apparatus. Assume your reader is an experienced chemical engineer. The experimental section should be sufficiently clear and complete so that a worker at a later time could repeat the experiments that you performed and obtain the same results.

5. Results

The Results and Discussion of Results sections are the most important in the report. The purpose of the results section is to present, in an objective form, the important facts derived from the observed data. Where useful for continuity or clarity, or other information may sometimes be included. This other material could be: some important intermediate results, a basic calculation method, or important assumptions used in the calculations.

Do not merely include tables or figures as the Results section. Tables and figures are merely illustrations that may be used to document the observations you are presenting to the reader. Do not make the reader interpret the illustrations; the interpretation should be provided by the writer. Present only the most pertinent (bottom-line) results; all details should be in the Appendix.

6. Discussion of Results

This should be a critical interpretation and theoretical and practical evaluation of the results. There should be a discussion of:

* The meaning, evaluation, and application of the results.
* The extent to which the objectives of the topic have been achieved.
* The reliability of the results, their accuracy and an evaluation of the source of error.
* A comparison of the results with those which might be expected in practice, or with those which have been obtained by other workers.

Interpretations and explanations are given.

In many reports, the results and their discussion are included under a single heading. In this course, however, the two should be separated so that the student may demonstrate that he can distinguish between the results and their discussion.

7. Conclusions and Recommendations

This section is included for the convenience of the readers and is a statement of the conclusions which have previously been developed in the discussion of the results. If the conclusions are distinct and discrete, and if there are many, they may be presented in itemized and numbered form. Any recommendations the writer wishes to make for improvement of the experiment may be included here.

8. Nomenclature Table (optional)

Summarize the nomenclature used in the report. Symbols are arranged in alphabetical order, first the Roman letters, then the Greek letters, then special symbols. The units in which each is expressed must be stated. If any symbols (in equations) or otherwise are used, they must be defined either in the nomenclature table or immediately following their first use in the text.

9. References

Books and articles referred to are listed in this section using a standard citation convention. This always includes, at least, all authors last names and initials, the journal, publication title, volume #, the year and the page. It can include the title of the article, the issue number and the page range. Use of “et al.” in place of author’s names is not acceptable. The two main conventions for the order of citations in your reference list are alphabetically by last name of first author, and by order of appearance in report body. Each has its advantages. If you choose the former, reference to the article in the report is by author(s) and year, e.g. Lewis (1927). If by the former, use the number from your reference list, e.g. [2].

Every book or article quoted in the bibliography must have one or more specific references in the body of the report. Do not include any reference in the bibliography unless you make a specific reference to it in the report. All figures, data and quotations from the work of others must be referenced. Be consistent with the format of the citations.
Example:
and

It should be noted that an increasing number of publications are also requiring the full title of the article. This is good practice, as it helps the reader to select material for further reading.

10. Appendices

Appendices should include any details not needed in main body of report – tables of data, more graphs, details of apparatus, procedure, sample calculations, raw data, etc. They may also include design problems, when given.

Photocopy data records must show the date, title of experiment, names of members of group, and signatures of persons who recorded the data. It is important to take the data neatly so that it can be checked by the reader. Collect and record in your data notebook all data that can possibly be used, being sure that you have the correct references to instruments, etc. It is difficult to obtain information after a test has been completed. A data book that cannot be read represents wasted time and energy. Make each record complete so that data can be fully understood, both by yourself and by others at a later date. The data book should be a record of the exercise or experiment as it was conducted; as such, nothing should be added to a data page at a later time without a written explanation and date. Avoid entering derived data except when needed for the experiment. Record new instrument readings - do not subtract tens, zeros, etc. in your head. Sufficient copies of the data should be made so that each group member will have a copy of the original data-book pages.

The sample calculations should be sufficiently detailed in theory, equations, methods and numbers so that a reader may reproduce your calculated results from the observed data given in the main body of the report with a minimum of effort. This requirement holds regardless as the method used to work up data. Include calculation of errors.

It is extremely important for all reports to be brief and to the point. For a major report Sections 3-9 should be limited to no more than twelve double-spaced pages of text, graphs and tables, and a schematic of the apparatus. All graphs and tables should be carefully chosen to help you reach your conclusions and recommendations. Other material may go into the Appendix.

Minor Report

The minor report should consist of:

1. Title Page
2. Abstract

3. Introduction (usually one paragraph maximum)

4. Results and Discussion

5. Conclusions and Recommendations

6. References

7. Appendices

For minor reports, sections 3-6 should not exceed three pages of text and may include no more than two pages of graphs or tables. Do not discuss the experimental part unless special problems occurred. Be brief.

Report Craftsmanship

The following rules for report craftsmanship should be followed to give reports a professional appearance and to make them easier to read quickly.

1. Reports are to be printed from a suitable word processor. Double-spaced, 12 pt printing should be used to facilitate inserting comments and corrections in grading. Very few insertions correcting typographical blunders will be permitted. Write on one side of the paper only. Leave adequate margins: 1.5” (left) and 1” (top, bottom and right). The report should always be submitted on 8-1/2 x 11 white paper. The report should be contained in a binder or folder of professional quality. For this course, the pages must be mechanically locked into the binder (do not use clamp-type binders). Keep a copy of your report.

2. The pages, including those carrying figures, should be numbered at the top center of the page. Lower-case Roman numerals (i.e., I, ii) should be used for the abstract and the table of contents. Arabic numerals should be used for all other pages except the title page, which is unnumbered.

3. All graphs and drawings should be neatly drawn or printed. A descriptive title and figure number (or table number) must appear in a conspicuous location (usually below) on each figure or table. Axes of graphs should be set well in from the margins of the paper so that no lettering need appear in the margins. Do not include illegible photo-copies of figures. All tables and figures must be referred to in the text; otherwise there is no need for them in the report. However, the contents of the tables and figures must be clear without having to refer to the report’s text. For a figure, for example, a poor title is “Heat-transfer Coefficient versus Flow Rate.” A better title is “Effect of Water Flow Rate on Overall Heat-transfer Coefficient in Methanol Condenser at 1 Atm.”
Use words **labeling** axes. Clearly the word “Pressure” instead of “P” is more informative. The units should be included in all figures and tables. Be careful about transforms of the data; for example, an axis labeled “Weight, lb x 10^6” could mean that a 1.0 on the axis scale is 1 x 10^6 lb, or 10^6 lb m, and ambiguous situation. Use the correct number of significant figures in all data. Additional guidelines for preparing figures and tables are given in the course textbooks.

4. Equations should be placed on a separate line and numbered to facilitate reference.

5. In writing the report, assume that the person reading the report knows as much as you did after reading the Introduction, when you started the work. Thus it is not necessary to make statements such as “…First, the pipe is screwed into the elbow…” since any fool (including your instructor) knows this. However, you should not give unfamiliar equations and data from the literature unless you give the origin and limitations of the material in question. Many researchers become so engrossed in their own subject that they forget that the average engineer is not familiar with the specialized work they are doing.

6. A major shortcoming in student report writing is that of being too wordy and including too much detail. The goal of the report is to present to the reader the necessary information so that he will understand what was done, why it was done, how it was done, and what was learned, but no more.

7. All written material must be the student’s own work; plagiarism or paraphrasing is not permitted under any circumstances. Figures or tables not originating from the writer(s) of the report must be referenced! Never use text from other’s work, even with a citation.

**Additional Hints for Writing Reports**

1. Prepare a detailed outline for major reports (1 or 2 pages). Do not hesitate to modify the outline as new ideas occur during the writing of the report. The report should explain the purpose of the work, place it in perspective relative to published information, describe the experiment, which was performed, and results, which were obtained, and present the conclusions which were reached.

2. Identify the tables and figures that will be needed to illustrate the points being made.

3. Write short paragraphs containing typically 3 to 5 sentences. Use subheadings to divide the report into logical units.
4. If there is the slightest doubt about spelling, consult the dictionary or an authoritative textbook. There is no excuse for misspelled words, especially when using a word processor.

5. **Hyphenate compound adjectives.** For example:

   a three-inch pipe, a copper-constantan thermocouple, a heat-transfer coefficient, a stirred-tank reactor.

6. Effective writing usually places the verb near the beginning of the sentence, close to the subject. Examples:

   **Poor**
   The mass-transfer coefficient, shown in Figure 1 as a function of temperature and compared with theory in Table 2, was calculated from Equation (3).

   **Better**
   The mass-transfer coefficient was calculated from Equation (3). Figure 1 shows the effect of temperature on that coefficient and Table 2 gives a comparison with theory.

   **Poor**
   The temperature of the liquid, the flow rate of the vapor, the pressure of the evaporator, and the power input to the motor were measured.

   **Better**
   The following were measured: liquid temperature, vapor flow rate, evaporator pressure, and power input to the motor.

7. **Use tenses carefully.** Use the past tense for acts that are now history and the present tense for results that are contemporary. Avoid the future tense; it is rarely needed. Example:

   The temperature of the vapor was measured with an iron-constantan thermocouple. Figure 1 shows the variation of vapor temperature with time.

8. **Short qualifying phrases are best placed at the beginning** of a sentence. Example:

   **Poor**
   The pressure of the evaporator was constant at 3 psia but it is difficult to say exactly because the pressure meter was flopping back and forth.

   **Better**
   Although the pressure meter fluctuated, the average evaporator pressure was nearly constant at 3 psia.
9. Use relative pronouns properly. In definite clauses (i.e., those necessary to identify the subject of the clause) the pronoun that is appropriate. Example:

The particle volume that was measured by displacement was greater than the calculated volume.

In non-defining clauses (i.e., those providing additional information about the subject of the clause) the pronoun which is appropriate, and the clause should be set off by commas. Example:

The measured particle volume, which was greater by 3% than the calculated volume, was used in the porosity determination.

10. Avoid unattached participles. Active participles require a subject except in rare circumstances where, by usage, they have acquired the power of adverbs (e.g., roughly speaking).

Poor
Substituting for x from Equation (6), the expression for velocity becomes:

Better
Substituting for x from Equation (6), we find the expression for velocity to be:

Or

With substitution for x from Equation (6), the expression for velocity becomes:

11. Avoid extra words. Consistent with clarity, use only the minimum number of words necessary to say what you want to say. After writing a paragraph, go back over it and remove all words that are not essential.

12. Use simple, direct words and sentences and avoid jargon or false elegance. Here is an example of a passage written by a sociologist on three characteristics of teenage culture:

   a. Compulsive independence of an antagonism to adult expectations and authority. This involves recalcitrance to adult standards of responsibility.

   b. Compulsive conformity within the peer groups of age mates. It is intolerable to be “different.”

   c. Romanticism: an unrealistic idealization of emotionally significant objects.

This wordy passage can be expressed by one simple sentence:
Teenagers tend to be disobedient, group-minded, and unrealistic.

Avoid essentially meaningless phrases such as

- It may be stated that…
- You will find it interesting to know…
- For your information…
- In this connection the statement may be made that …
- At this point in time it may be appropriate to…
- In order to…

Avoid generalities: be as specific as possible. Also whenever possible, be quantitative rather than qualitative and positive rather than negative. Examples:

**Poor**
The temperature measurement was not accurate because the thermometer was no good.

**Better**
The accuracy of the temperature measurement can be improved by better thermometer calibration.

**Poor**
Figure 1 shows that the data are in bad agreement with the results calculated from Equation (3).

**Better**
Figure 1 shows that the experimental heat-transfer coefficients are about 60 percent larger than those predicted by Equation (3).

Additional examples of proper writing style are contained in the ACS Style Guild.