TECHNISCHE UNIVERSITÄT MÜNCHEN
DEPARTMENT OF CHEMISTRY
CHAIR OF PHYSICAL CHEMISTRY
Dott. Ric. Michele Piana

WS 2018/19

Laboratory Course in Physical Chemistry for Students in Bachelor of Education (Math-Chemistry) - 5th Semester

Important information for the participants

Lead and coordination

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In collaboration with:

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To know before the laboratory course

Prerequisites for participation:

- **Registration and attendance** to the lectures in Physical Chemistry I.
- **Knowledge** of the experiments in chemical thermodynamics and kinetics through the available script. This will be checked in a test before carrying out every experiment. Large lack of knowledge will result in rejection from the laboratory course.
- Valid laboratory **liability insurance** (Haftpflichtversicherung).
- Knowledge of the **laboratory regulations**.

Structure of the course: the laboratory course is divided into 8 sessions:

- An **introductory seminar** (Einführung in die Fehlerrechnung und Sicherheitsbelehrung), **mandatory**.
- **7 experiments** in the lab, 5 about thermodynamics and 2 about kinetics (assigned before the beginning of the course, not to be chosen by the students).

Language of the course: English is encouraged as language for the course, for the students to practice the international language in science. It is mandatory only in case of not-German-speaking supervisors.

Weekdays of the course: this laboratory course will be hold on Fridays in one session from 9:00 (see the table below for the exact list of the days).

Registration: on TUMonline (Physikalisch-chemisches Praktikum) the students need to register for the exam (**Prüfung CH1208**). **Deadline: 30.09.2018.**

Choosing a laboratory partner: starting on 05.10.2018, the students should choose a laboratory partner on the portal praktikum.ch.tum.de (login with TUMonline credentials) using the "Team" function. **Deadline: 12.10.2018.**

To know during the laboratory course

Laboratories for the course: rooms CH 23403 & CH 23411.

Script: available from 15.10.2018 to 19.10.2018 for picking up on working days from 9:00 to 12:00 at the office CH 43104 (digitally available also at http://www.tec.ch.tum.de/index.php?id=3426). Comments and corrections of typos on the script are welcome.

Schedule: the table below reports the dates and times for the different appointments. There is an extra day at the end of the course for making up for **one possible absence** without justification **for each team** of students.

Schedule	***Fridays at 9:00***	***Report deadline***
Introductory seminar (error estimation)	**16.10.2018 at 16:15 in CH 27402 (Walter-Hieber-Hörsaal)**	
1st Experiment	19.10.2018	26.10.2018
2nd Experiment	26.10.2018	02.11.2018
3rd Experiment	09.11.2018	16.11.2018
4th Experiment	16.11.2018	23.11.2018
5th Experiment	23.11.2018	30.11.2018
6th Experiment	30.12.2018	07.12.2018
7th Experiment	07.12.2018	14.12.2018
Extra day	14.12.2018	21.12.2018

Preparation for each experiment:

- **Theoretical background** to acquire with the support of lectures, laboratory-course script and course books on Physical Chemistry (e. g., Atkins).
- Before each experiment, the students should **prepare a datasheet** (Excel is the software available on the computers in the laboratory) to record the experimental

data and their mathematical manipulation using the corresponding equations. The students should also be prepared to plot a graph using the collected and mathematically analyzed data in order to depict preliminary results and to discuss them with their supervisor.

Important rules for the laboratory course:

- **Delays** of more than 15 minutes must be agreed with the supervisor of the corresponding experiment. In case of unjustified delays, the experiment will be performed on the extra day (at the end of the course).
- There is **only one extra day for each team**, not for every participant. The students of **one team should always perform the experiments together** (teamwork).
- **A signature by each student** on a list kept by the technicians **must confirm his/her presence** for each session. Please sign this list at the end of each experiment.
- **Please send the data** right after finishing the experiment to the corresponding supervisor **via e-mail** (contact information is available in the experiment assignment).
- The schedule reports the **deadline for the delivery of the report by e-mail** for each experiment (**at 24:00** on the days reported in the table). For **each two days of delay**, the points for the corresponding report will **decrease by 1 point**. This is to assure a fairer grading between the teams and to help students and supervisors to avoid accumulation of reports to write and read, respectively. Filename of the report in the form of *Surname1-Surname2_dd.mm.2017* (date of the experiment).
- The supervisors may ask the teams for a **second corrected version of the report**, in order to clear big mistakes, add missing parts and fill the gaps. **This does not mean that the grade will be increased after the second version.**
- The **final oral test can be taken** only **after delivery of the last report**. The teams have to make an appointment with the responsible supervisor.

During the experiment:

- **At the beginning**, while the teams are becoming familiar with the equipment listed in the script and are setting up the experiments, the supervisors come by in order to perform the **preliminary oral test**. This test evaluates the knowledge of both **experimental execution (20%**, including the discussion of the prepared **datasheet) and theoretical background (60%)** of the experiment of the students. In the grade will be included also the student's behavior during the experiment regarding **laboratory safety (20%)**.

- After showing the **prepared datasheet** to the supervisor and **discussing its applicability**, during the experiment, the student must paste the data in the datasheet and analyze them mathematically right away.
- Only after passing the preliminary oral test and after the supervisor checked the datasheet, the students can start to collect data on the experiment.
- **At the end** of the experiment, the teams must **check and leave the equipment clean and intact**. Please report every damage to your supervisor. Before the students are allowed to leave, the supervisor must check the equipment.
- After the experiment, each team needs to **discuss the collected experimental data** and the preliminary graphs **with the supervisor**.

Report (see the model below): in **a clear, compact and neat** written document, the teams must report:

- **A short introduction to the experiment** including **the aim and the theoretical background** of the experiment (what was measured in the experiment and how, the students should use their own words, to copy and paste is not allowed).
- A short description of the **experimental execution**, in chronological order.
- The **results and their discussion**, starting from the datasheet and graphs drafted during the experiment to **report the data and their analysis**. Here the students need to **include the error** of the measurements (never forget the units) by performing a correct **error estimation and propagation** (as explained in the introductory seminar). Make sure to use the **correct number of significant digits.**
- **A conclusive discussion** on the experimental results. A plus for the students would be the **comparison of the data with scientific literature** and the **awareness of practical applications** (different from those reported in the script).
- A **short summary** of the conclusions to complete the report.
- English is encouraged as language also for the report, so that the students can practice the international language in science. It is mandatory only in case of non-German-speaking supervisors.

Final oral test: At the end of the course the knowledge applied in the experiments, in terms of its theoretical context (please review the lectures in Physical Chemistry I), is evaluated by one of the supervisors. The test deals with the **fundamental understanding of the thermodynamics** of the experiments and not with their technical experimental details. **The fundamental understanding of the kinetics** will regard only the performed experiments. The oral test has an approximated time of **20 minutes for each student** and is held with the team partner as witness. The **latest deadline** for the final oral test will be **19.01.2019**.

Grades: in the evaluation are included

- All the questions before the experiments (preliminary oral tests) and the execution of all the experiments (45%).
- All the reports for each experiment (23%).
- One final oral test at the end of the laboratory course (32%).
- After the end of the course, the supervisors will upload the grades on the portal praktikum.ch.tum.de.

We wish all the students good luck for the laboratory course. Enjoy the experiments!

Dr. Michele Piana and Dr. Alex Ogrodnik

Mandatory model of the written report

Structurally, the report of an experiment should follow the guidelines of a scientific publication. Indeed, different publication media show different structures, however, the one given below is the most popular one and the most convenient for our needs.

For clarity, it is important to introduce a **footer on each page of the report**, which must include **page number, names of the students, group number and indication of the semester** (e.g., WS 2018/2019).

English is encouraged as language also for the report, so that the students can practice the international language in science. It is mandatory only in case of non-German-speaking supervisors. The students should always **use their own words**, copy and paste is not allowed.

What matters is not the number of pages of the report but the fact that **all the requested points are listed with good quality**.

Title page

The title page has to **include all the information necessary** to classify the report: name of the laboratory course, indication of the semester, title of the experiment, names of the students, group number, indication of the field of study and date of the experimental execution.

1. Introduction

1.1 Aim of the experiment

One or two sentences to depict the aim of the experiment: **what is measured** in the experiment and **how**.

1.2. Theory

A short paragraph to **summarize the corresponding theoretical background** necessary for a full understanding of the experiment: short description of the **applied method** (why is it the method of choice) and indication of the **relevant equations** (without giving any derivations, just refer to scientific articles, books or the script of the laboratory course). The equations should be numbered, so that the students can refer to them in the evaluation part.

2. Experimental setup and execution

Short description of any **problem or discrepancy with the script** of experimental setup, execution or relevant measuring conditions (temperature, pressure, concentrations, etc.) that would affect the results.

3. Results

- **Compact and comprehensible analysis/evaluation** from the raw data, including all important calculations, results and references to the equations. The results should be depicted, preferably, **graphically** (starting from the graphs drafted during the experiment). Any long **tabular form** of the results should be minimized or moved to the appendix. In the analysis/evaluation part it is important to include **the error of the measurement (using the correct number of significant digits)**, since the indication of errors is essential for the reliability and evaluation of the results. For clarity, the **detailed implementation** of the error estimation and propagation is **shifted to the appendix**.

Generally, it is very important not to forget **units** and, in graphs, **axes labelling and error bars** (incompleteness and errors will lead to a much lower grade for the report!).

4. Discussion

Compact and clear discussion of calculations and results including

- The students must address **all the points requested** in the paragraph **"Data evaluation"** of the script.
- **Interpretation:** depiction of the **scientific meaning** of the results and alternative interpretations in the case of unclear results.
- **Discussion** of the **significance of the results and the corresponding errors** (is the pursued goal achieved?). A plus for the students would be mentioning **alternative methods** that could probably lead to improved results, a **comparison of the data with scientific literature** (never forget to cite an appropriate source, i. e., not Wikipedia but a correct scientific reference there listed) and the **awareness of practical applications** (other than those reported in the script).

Actually, this chapter is the most important part of a scientific publication or report. However, based on the short experiments of a laboratory course, it is not easy to create an extensive analysis of the results and compare them with the literature. In their reports, the students may thus use this chapter to **speculate** and to formulate **open questions** and **hypotheses**.

5. *Appendix*

- **Detailed and comprehensible calculations:** Tables need to be clear and compact, try to minimize their number; do not forget to number the tables (legend) and to give the unit of all values.
- **Full-page plots,** only if necessary.
- **Error analysis:** Remember that errors are not a deficiency but a measurement's seal of quality! The error analysis must include:
  - Indication of the error of all measured data (according to the estimation during the experiment).
  - Indication of the error of intermediate calculations and results obtained by executing an **error estimation and propagation** (as explained in the introductory seminar). Make sure that the arrangement is clear and, if necessary, use tables. In the case of **linear plots**, both a graphical error evaluation (steepest and shallowest line) and a weighted linear regression are desired, including a comparison of the obtained errors.
  - Always think about whether the **dimension of the errors** is meaningful. Discuss the reasons for too small and non-significant errors, as well as additional sources of errors, if the estimated errors are clearly greater than expected.