THERMODYNAMICS PROJECT

SYLLABUS PROJECT QUARTER 4
CHEMISTRY

MOLECULAR SCIENCES
2019

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website
1. Orientation on the project

1.1 Subjects

In this project, the aim is to test and apply the laws of (chemical) thermodynamics. The concepts of internal energy/enthalpy on the one hand and entropy on the other will play a central role. Both the opposing role of the energy and entropy in chemical reactions, and their role in the conversion of energy will be examined. The role of the internal energy will furthermore be examined in the generation of electricity.

For the optimal broad scope of this project, it is split into four subprojects.

1. Energy versus enthalpy
2. Enthalpy versus entropy
3. Electrochemistry
4. Blue energy

Besides the testing of the laws of thermodynamics, covered in the Thermodynamics lectures, we will have a stronger focus compared to other projects on the following three aspects:

- How can you work as a team?
- How well can you set up an experiment to solve a problem?
- What is the effect of the measurement errors for the results?

1.2 Method

The content of this project is directly related to the theory covered in the Thermodynamics lectures. Not only will you be able to strengthen your knowledge of the theory by doing group wise experiments, but also build up your experimental skills for the field of physical chemistry. You will furthermore learn to set up a reliable experiment by individual reasoning, consulting textbooks/internet and consulting your colleagues and assistant. Questions like “How can I maintain a sufficient level of accuracy in my experiments” will play an important role. You will eventually be limited in your choices of experiments by the available equipment and chemicals, which you should interpret as a challenge.

1.3 Activities

For all five subprojects you will work, where possible, in couples. Six or seven couples make up a project group. For each of the subprojects the couples choose from a couple of experiments. Depending on the subproject, the distinctions between the experiments will be in different reactions, different equipment and tackling different problems.

Together with your partner, the rest of the project group and the assistant you will choose with which questions and goals you will be setting up and performing the experiments. After the experimental part, the results are group wise shared and compared to the theory.
1.4 Project based
In the previous projects you already experienced more freedom in choices, planning and organization. These aspects will be even more prominent in this project. A lot of independence is expected of the student in the preparation for the subprojects in the preparation, choosing an experimental design and execution of the experiment. The role of the assistants will be more correcting and adjusting than directing. They are however still responsible for the safety; the assistants are to decide if an experiment can be performed.

1.5 Reports
For each subproject, a report will be handed in by each of the student couples. The report should be to the point and contain a report of the experiment of the couple as well as the results of the other couples and a discussion of the different results along the group. The experiment of the couple itself will be the most prominent in terms of experimental design, execution and results. The acceptance of the subproject report by the assistant completes that subproject. The reports can act as a basis for the presentation at the end of the project during the final symposium. The report has to be handed in to the assistant at the beginning of the next subproject or earlier.

2. General Information
2.1 Project coordination
Hugo Meekes
Room: HG03.625, phone: (36)53200; <email_address>

Assistants:
TA-1 TBA
TA-2 TBA
TA-3 TBA

Practicum coordinator
Tom Bloemberg, practicum leader
phone: (36)53452; <email_address>

2.2 Study load and scheduling
A total of 13 days have been scheduled for the chemistry students during this project. Each subproject takes three days, which includes writing the report.

The distribution of the subprojects over the project days can be found in a separate schedule for each of the groups. The locations are also to be found in this schedule.

The project will be concluded with a presentation (and poster) during the first year’s symposium.
2.3 Study material
The book ‘Physical Chemistry’ (P.W. Atkins) will serve, together with the study guide of Thermodynamics, as a theoretical handbook for this course. No further literature will be provided. Finding the appropriate information is up to the students. The Library of Science and the internet can provide useful additional sources of information. All further information can be found on the website of the project.

2.4 Project groups
Fourteen to seventeen students will form one project group and will be assisted by one assistant. For each subproject the students will form (alternating) pairs (one group of three in case of an odd number of students). The assistant will guide the same group for the full duration of the project.

2.5 Planning
Since the results of the different couples should be exchanged and evaluated, a good planning is required. The planning should be done in the group discussions. The assistant is only expert on the background. He/she will make sure the process will be efficient and safe.
Divide the available time per subproject over the following:

- Day1: Preparation, gathering and reading relevant information
- Day1: Setting up the experiment
- Day2: Executing the experiment
- Day2,3: Temporary report
- Day2,3: Exchange with other pairs
- Day3: Definitive report.

The assistant will judge the planning and adjust it as little as possible.

2.6 The lab notebook
You should personally keep updating your lab notebook (so two lab notebooks per couple) during the project. This is essential, due to the freedom in experimental design, and to analyze unexpected results. The assistant will regularly look into your lab notebook to see if your registration of experimental work can/should be improved.

3. Content and relevance
Performing experiments is an essential part of your scientific education. Experiments are an important tool to improve your scientific insights. You can formulate questions and hypotheses based on experiments and answer them by new experiments. More than in previous projects, you are expected to realize that doing experiments on an academic level does not only include that you execute the experiment but even more so that you come up with a good experiment. It is important that you question yourself which equipment and chemicals you need and how much time and money this will cost, but also how safe it is. Reliability of your experiment is also essential. Besides that, the way you report and communicate with the outside world is of great importance. Your
experiment gets its value by informing others about it, and their opportunity to respond to it. Knowledge about experimenting is not only important for the scientific researcher. You will be able to judge an experimental work and results of others, only if you focus on it during your education. For an educated chemist, experimenting will mainly involve the manipulation of chemicals and equipment. The equipment is often costly and dangerous. Think twice before you, for instance, plug in your equipment, not only for your own safety but also to prevent damage or explosions of hydrogen gas due to sparks. Consult your assistant in any case. Besides that, the academic level of the experiment will be significantly higher in this project. You will be challenged to independently set up and execute an as good and reliable as possible experiment within the limitations of this project. You will be working on the border of chemistry and physics, a field which has broad applications. In the fourth subproject (Blue Energy), you will be dealing with a topic which is very important for society. The increasing demand for energy is an undeniable aspect of our current political, social, industrial and therefore scientific discussion about new sources of energy.

4. Requirements and goals
Requirement:
You have to have followed Thermodynamics actively, because this project directly follows the content of that course. A deficiency in the insights of the abstract terms from this course will be tested by the assistant.

Goals:
At the end of this project you will have learned how to translate a scientific question to an executable experiment. You have learned to estimate how the experimental uncertainty affects the results. You will have shared your experimental results in the project group, and together addressed the common problem(s). You will be able to independently (be it as a couple) write reports on your results and those of your colleagues. Furthermore, you will have tested the underlying principles of (chemical) thermodynamics by setting up relevant and reliable experiments.

5. Specific information about the how the project is setup
General
You will divide the chosen experiments within a subproject as a group. Realize that each experiment involves two people to be executed. Good communication between those couples is vital.

Protocol
In the first quarter you have bought a safety manual. It is expected that the content of this manual is known and understood by the students. At the beginning of each subproject you will have to ask yourself which parts are relevant, and write them down in your lab notebook.
A variety of chemicals will be used. You are expected to be familiar with the dangers of each of the chemicals that you will work with during the subproject (for instance hydrogen gas!). You should know how to safely work with those chemicals, and it should be written down in your lab notebook. Clearly include which measures you have to take to reduce the risks (like wearing gloves).

For your safety and that of others, working with a safe and secured setup is essential. Making mistakes in the connection of tubes and cables can easily lead to accidents. To prevent this as much as possible, you will have to orientate how to do the experiment during the preparation. Make a simple sketch of your setup in your lab notebook.

All previously named safety aspects and proposed experiments will be discussed as a group, to reduce the risk of an accident. It is obvious that the judgment of the assistant is important in safety related issues, and that his or her opinion can be binding. He or she is responsible for the safety of an experiment.

No experiment may be started without his or her permission.

6. Assessment

The assessment of each subproject will be based on the following elements:

- Your individual performance during the preparation and setup of the experiment
- Your individual performance during the execution of the experiment
- Your participation in the group discussions
- The report

A detailed version of the assessment diagram is included (page 8)

7. Evaluation

Each subproject will be concluded with an evaluation and suggestions for improvement. Points of discussion can include:

- Did the experimental setup work sufficiently?
- Are the measurements unambiguous enough?
- Did the theoretical questions get enough attention?
- Were all earlier noted aspects addressed enough?

This evaluation will take place during the third (report) day of each subproject.

Moreover, there will be a general online evaluation of the whole project. Filling in this online evaluation is both important for yourself and for participants in the years to come.

8. Code of conduct

Like in earlier lab courses the Code of Conduct gives you the rules on issues like obligatory presence, communication, safety, clothing or plagiarism. You are expected to behave according to this code.

The code of conduct is also present on the website of the project.
ASSESSMENT DIAGRAM THERMODYNAMICS PROJECT, SUBPROJECT 1-4

<table>
<thead>
<tr>
<th>IND./ GROUP</th>
<th>ASPECT</th>
<th>PRODUCT</th>
<th>ASSESSOR</th>
<th>CRITERIA</th>
<th>%</th>
<th>ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1</strong> Individual (couples)</td>
<td>Theoretical knowledge and preparation experimental design</td>
<td>Experiment proposal Overview of dangerous aspects and precautions to be taken (lab notebook) Relevant data (in lab notebook)</td>
<td>Assistant</td>
<td>• Understanding of matter • Inventivity • Completeness • Clarity • Sketch of setup</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td><strong>Phase 2</strong> project group</td>
<td>Exchange research proposals and distribution of experiments</td>
<td>Planning Experiments to perform per couple Conditions for a safe and reliable experiment</td>
<td>Assistant</td>
<td>• Communication • Planning</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td><strong>Phase 3</strong> Individual (couples)</td>
<td>Working out experimental setup Measurement</td>
<td>Experimental setup Experimental results</td>
<td>Assistant</td>
<td>• Planning • Skill • Tidiness • Safety</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td><strong>Phase 4</strong> project group</td>
<td>Exchange results</td>
<td>Participation in couple-combination and project group</td>
<td>Assistant</td>
<td>• Communication</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>Phase 5</strong> Individual (couples)</td>
<td>Writing report</td>
<td>Report</td>
<td>Assistant</td>
<td>• Analysis and interpretation of results • Processing of input from group members</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>