1. Introduction – Lab Journal

Your friends and you are going on a Sunday picnic. The sun is shining, and it is finally time to relax. You've chosen a secluded forest area as your destination - because, well, you are into adventure! Arriving deep in the forest, you discover an old house. Just at this moment, a scream comes from this house. "Let's go see if anyone needs help!" someone calls out. You enter the house and discover a person in a lab coat propped up on the ground. After a brief moment of shock, you pull yourself together and try to get a handle on the situation. No, of course, you don't take selfies in the old chaotic lab and especially not with the unconscious scientist. Instead, you call the emergency services, give first aid and take on the challenge of deciphering what actually happened here. On the phone, you learn that the rescue service won't arrive for at least an hour.

You see the flashing countdown displaying 70 minutes. Next to it is a note: "If this time expires without me having taken the next step of the experiment, the work of my life will be for nothing". You agree that you should help the scientist. Full of curiosity, you go through the laboratory and discover a lot of tips about his experiment.

2. Experiments

2.1. Lemon Battery - Electricity from Fruits?!?

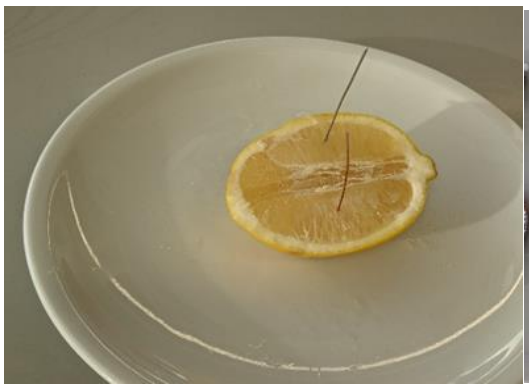
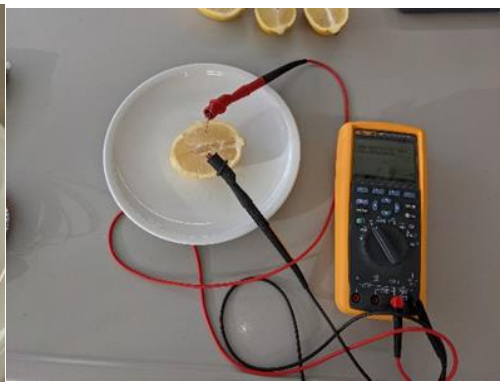
On the other side of the lab, you discover a whiteboard that is - strangely - completely blank. Next to it you discover some black light pens. You get the idea that UV light could be necessary to make the writing on the whiteboard visible. Maybe the scientist was afraid that someone would steal his ideas and results? But where could he have hidden a black light lamp? After a long search, you finally discover the UV lamp! However, it doesn't turn on - apparently the batteries are empty... Generate electricity from the lemons you packed for lemonade to power the lamp!

Equipment needed:

- 2 lemons
- Multimeter (with cables)
- Electrical cables, possibly additional clamps
- Copper wire
- Zinc wire oder galvanized wire
- Knife (for cutting the lemons)

Implementation – lemon battery with one lemon half

1. Cut the lemons in half.
2. Insert one copper wire and one zinc wire into the lemon half.
3. Connect the wires to the multimeter. Use additional clamps if required. If the multimeter has cables, you can use them as well.
4. Switch on the multimeter and select the appropriate measurement mode.

Task

- Build a lemon battery consisting of one lemon half and measure the voltage with the multimeter.
- Enter the measured value in the table.

Implementation – lemon battery with several halves:

1. Put a copper wire and a zinc wire into each lemon half and put the lemon halves next to each other.
2. Connect the copper wire of one lemon half with a cable to the zinc wire of the other lemon half.

3. Now the electrical circuit must be closed: use the cables and possibly clamps for this.

Tip: To avoid short circuits, always connect copper and zinc wires (not e. g. a copper wire with a copper wire).

Tasks:

- Use two or three lemon halves connected in series to build a lemon battery with more than one lemon half.
- Measure the voltage using the multimeter and enter the values in the table.

Arrangements of lemons	Voltage / V
1 half	
2 halves, series connection	
3 halves, series connection	

Puzzle:

Tip: Use the measured voltage values of the lemon batteries and your knowledge from class.

Which order is correct?

Solution A (corresponds to code: 2) $U_{3\ \text{lemons, in series}} > U_{2\ \text{lemons, in series}} < U_{1\ \text{lemon}}$

Solution B (corresponds to code: 9) $U_{3\ \text{lemons, in series}} > U_{2\ \text{lemons, in series}} > U_{1\ \text{lemon}}$

Solution C (corresponds to code: 1) $U_{3\ \text{lemons, in series}} < U_{2\ \text{lemons, in series}} < U_{1\ \text{lemons}}$

Solution D (corresponds to code: 3) $U_{3\ \text{lemons, in series}} = U_{2\ \text{lemons, in series}} = U_{1\ \text{lemon}}$

2.2. Searching for traces using UV light

After successfully getting the lemon battery to work, you find new batteries in the depths of a drawer. Use one of these batteries to light up a small UV diode and look for the next hidden clue.

Materials needed:

- UV LED diode
- Batteries and adapter
- Electrical cables and possibly clamps
- UV protection glasses or sunglasses

Execution of the experiment:

1. Put on the UV protection glasses or sunglasses.
2. Install the batteries in the adapter.
3. Connect the LED diode to the battery using the clamps (and cables if necessary). Make sure you connect the diode the right way around.
4. And now go in search of clues! Look for the next clue with the UV LED diode.

Tip:

Some traces are invisible to the human eye. Under UV light, however, they may start to glow. Maybe you will find the next clue for the code!

2.3. pH-Experiment

Be careful! The scientist was a bit sloppy again when labeling his containers in the acid and base cabinet. Use your knowledge of acids, bases and the pH value to identify the right liquid!

Materials needed:

- 4 test tubes with unknown liquids
- Universal indicator paper with color scale
- Test tube holder
- Glass rod

Execution of the experiment and task:

- You discover the following note in the lab journal: “Important: neutralize solution X! (test tube with required amount was already prepared). Check with indicator paper." But next to the beaker of solution X are 3 test tubes. From class, you know neutralizing has something to do with pH, which has a scale from 1 to 14. Next to the beaker is a yellow strip of paper and a color scale numbered from 1 to 14. That must be this indicator paper.

- **Your task:** Determine the pH value of solution X and the solutions in the test tubes by placing a drop with the glass rod on a piece of indicator paper. Dip the glass rod into a glass of water between each liquid and dry the glass rod with a paper cloth. Record the color and corresponding pH value in the table. Which solutions are acidic, neutral or basic?

Question:

Which test tube neutralizes solution X?

Verification:

Pour the content of the selected test tube into the beaker for solution X to check the result and measure the pH value of this solution after stirring with the glass rod.

The code is the number on the test tube.

2.4. Dilution series - The human eye as an analytical instrument?!

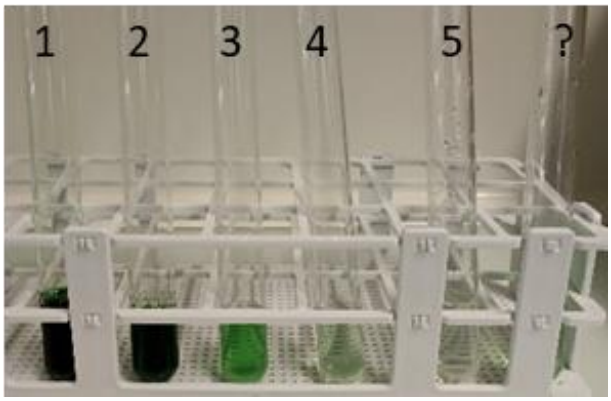
Next to the vessels with the odors is another flask containing a green liquid. This liquid has to be mixed with other substances for the next reaction step. To do this, the liquid needs to be added in the same concentration as it is in the flask. However, the remaining amount in the flask is no longer sufficient for the reaction. To solve the problem, you only have a concentrate of the green liquid. Create a dilution series to determine the correct concentration and thereby obtain an important clue!

Equipment needed:

- 5 test tubes
- test tube rack
- 10 mL measuring cylinder
- pipettes
- 100 mL beaker filled with water
- 100 mL beaker for waste
- concentrated dye solution
- unknown dye sample in a test tube
- permanent marker
- notepads, pen, calculator

Experiment instruction:

1. Place the 6 test tubes (TT) in the test tube holder and mark them in sequence with the numbers 1 to 5 and a question mark.
2. Fill the unknown sample into the test tube labeled with the question mark.
3. Measure out 10 mL of the dye concentrate and transfer this to the test tube with the number 1 (TT1).
4. Using a pipette and the rinsed graduated cylinder, transfer 4 mL of solution from TT1 to TT2. Note: Pipettes can continue to be used for the experiment after rinsing with water.
5. Fill TT2 with 6 mL of water and homogenize the solution by carefully shaking and swirling. Use the rinsed measuring cylinder for this purpose.
6. Repeat steps 4 & 5 with the newly prepared solution until you have obtained a dilution series with a total of 5 solutions (photo).



Task:

Determine the concentration of the unknown sample using the dilution series prepared!

1. Assign a solution from the dilution series to the unknown sample (TT?). Note: To do this, match the color intensity of the test tubes and assign those with the most similar color impression to each other. Make sure that you observe all test tubes under identical light conditions, with the same background and perspective.TT? corresponds approximately:
2. Determine the concentration of the unknown solution using the following table and the dilution steps performed. If necessary, use another sheet for secondary calculations.

test tube	dye concentration / mg/L
TT1 (=concentrated dye)	250
TT2	
TT3	
TT4	
TT5	
TT?	

Find the correct number for the code:

The concentration of the dye in the unknown sample has the following concentration:

- Variant A: concentration = 40 mg/L and code: 3
- Variant B: concentration = 16 mg/L and code: 2
- Variant C: concentration = 6.4 mg/L and code: 8

2.5. Precipitation Reactions

As you have been informed by some information on the whiteboard, you now have to obtain a solid in a chemical way. Any idea how this will work?

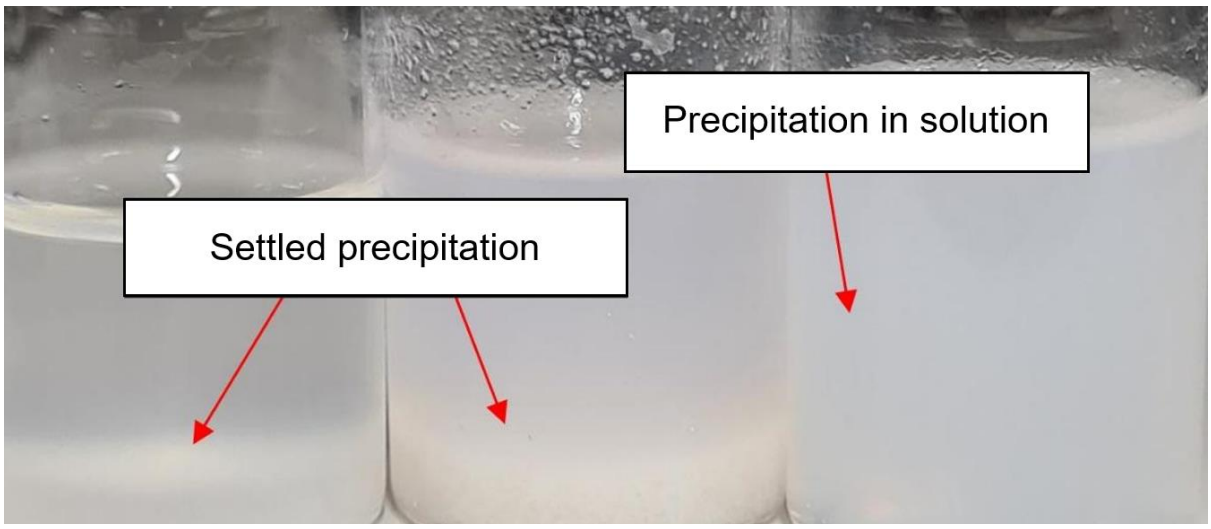
Stick to the experimental procedure and observe carefully!

Equipment needed:

- 4 test tubes with metal salt solutions (prepared by the teacheror you will receive salt solution you have to transfer in the test tubes (around 3 mL needed of each salt solution). Do not forget to label the test tubes).
- 1 M NaOH (~ 10 ml per group)
- pipettes

Experiment instruction:

1. Add about 0.5 mL of 1 M NaOH to each metal salt solution using the pipette.
2. For each metal salt, write down your observations on the following criteria:
    - Is a **precipitate** visible after adding 0.5 mL NaOH each time?
    - **color** of precipitation
3. Repeat step 1 four more times and note which metal salts cause the precipitate to dissolve again by adding NaOH several times.



Hint 1:

Concentration gradients can falsify the result. To avoid concentration gradients, the test tubes should be closed with a stopper and shaken after each addition of NaOH.

Hint 2:

Precipitation is the settling out of a sparingly soluble solid from a solution. However, a fine solid distributed in the solution also counts as precipitate (see figure).

Task:

Compare your observations with the following solution variants. In which of the following variants are **all** three statements **completely** correct:

Variant A (Code: 3)

- The aluminum salt precipitates blue-green.
- For sodium chloride, no precipitation can be observed at any time.
- The precipitation of the iron salt remains even after multiple additions of NaOH.

Variant B (Code: 7)

- The iron salt precipitates grey-green.
- No precipitation can be observed for the aluminum salt at any time.
- The manganese/barium salt* precipitates white.

Variant C (Code: 6)

- The precipitation of the manganese/barium salt* remains even after multiple additions of NaOH.
- For sodium chloride, no precipitation can be observed at any time.
- The precipitate of the aluminum salt redissolves after several additions of NaOH.

* You will be given either a manganese or a barium salt, depending on the availability at your school.

2.6. Aroma memory - smelling the molecules

Various small vials are lying around on the work surface of the laboratory, with small labels in between. Unfortunately, the scientist didn't manage to stick the labels on the containers appropriately. Well, grab the goggles lying in a drawer and find out what each vial contains - by smelling it chemically! Look closely at the stereochemistry of the target molecule and you'll get a clue to solving the puzzle!

Materials needed:

- 4 snap lid jars with aroma oil and element symbol
- fragrance card

Experiment:

1. Sniff at the different samples by opening the lids separately, without changing the order.
2. Match the smells. The four smells match the suggestions on the scent card. Choose the correct four!

Task and puzzle:

- Note the fragrance number (number in the bottom left corner) in the table below.

Element symbol on snap lid jar	**C**	**H**	**N**	**S**
Fragrance card number				
Number of atoms in the target molecule	carbon	hydrogen	nitrogen	sulfur

- From the table, you can determine a molecular formula. This fits one or more structural formula shown on the fragrance cards. You have to find these fragrance card(s).
- Now, crack the code: Find the stereocenter in the respective structural formula. The position of the stereocenter, the little red number, is part of the final code.