

First name .....

Date .....

Last name .....

Degree program name .....

## Exercise B07

### Measurement of changes in CO<sub>2</sub> concentration - Photosynthesis

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Table I: Assessment of the rate of CO<sub>2</sub> concentration change in dark and light conditions .....

Temperature in the laboratory before measurements  $t_p = \dots\dots\dots$  °C,  $T_p = \dots\dots\dots$  K

Bottle volume ..... ml

No. <b>measurement</b>	Slope factor (dark phase) m [ppm/min]	Slope factor (light .....) m [ppm/min]	Change in CO <sub>2</sub> * concentration (dark phase) $\Delta C_z$ [ppm]	Change in CO <sub>2</sub> * concentration (light .....) $\Delta C_s$ [ppm]
1				
2				

\* To calculate the change in CO<sub>2</sub> concentration, subtract the final CO<sub>2</sub> concentration from the initial CO<sub>2</sub> concentration. Record the results as absolute values.

Measurements 1:

Correlation coefficient (dark phase),  $r_{c1} = \dots\dots\dots$

Correlation coefficient (light .....),  $r_{s1} = \dots\dots\dots$

Measurements 2:

Correlation coefficient (dark phase),  $r_{c2} = \dots\dots\dots$

Correlation coefficient (light .....),  $r_{s2} = \dots\dots\dots$

Temperature in the laboratory after measurements  $t_k = \dots\dots\dots$  °C,  $T_k = \dots\dots\dots$  K

## Exercise B07: Measurement of changes in CO<sub>2</sub> concentration - Photosynthesis

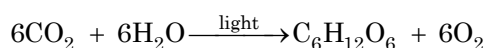
### TARGET

The aim of the exercise is to answer the question: does lighting affect changes in CO<sub>2</sub> concentration in the presence of green leaves?

Please note that the leaves used are plucked.

### TEORIA

Plants and other organisms use solar energy to build complex organic compounds that serve as a source of energy for the body. The basic substrates used by plants to produce food are two simple inorganic compounds: H<sub>2</sub>O and CO<sub>2</sub>. Land plants get water from the soil and carbon dioxide from the air. These compounds produce a simple sugar - glucose. The process of converting H<sub>2</sub>O and CO<sub>2</sub> into glucose occurs in the presence of light. This process is called photosynthesis (the name of this process comes from the Greek words phos (light) and sýnthesē (creation)). Ultimately, through light-independent reactions, chemical energy is transferred and stored in molecules such as glucose. The entire process is summarized by the chemical equation:



The uptake of carbon dioxide indicates that photosynthesis is taking place in the leaf's chloroplasts. Reactions that fix carbon into organic compounds depend on the products of light reactions and therefore depend on the absorption of light by pigments. Although sunlight is composed of many different wavelengths of light, not all wavelengths are equally available to the plant. This activity compares the intensity of photosynthesis occurring when light is present or absent.

Carbon dioxide is the basic substrate of photosynthesis. Its concentration in the atmosphere is approximately 0.04% (400 ppm). The main sources of this gas are the decomposition of dead organic matter in the soil, carried out by bacteria and fungi, and human activity. The amount of CO<sub>2</sub> in the air affects the intensity of photosynthesis - therefore, an increase in its concentration leads to an increase in the mass of plants. However, the intensity of the process increases only up to a certain level of saturation of the plant with this gas. Once it is achieved, a constant rate of photosynthesis is established, which depends on other factors, mainly the rate of reactions carried out by cellular enzymes.

The notation of the ratio of two quantities is a symbol used to write the dimensionless ratio of two numbers or numerical values of two quantities with the same units. Such ratios can be written as percentages (symbol: %, number of parts per hundred) or permille (symbol: ‰, number of parts per thousand). In many fields of science, other symbols are used, including: ppm (parts per million, 10<sup>-6</sup>), ppb (parts per billion, 10<sup>-9</sup>), and ppt (parts per trillion, 10<sup>-12</sup>).

### *Fun Fact 1*

Plants can process 10x more CO<sub>2</sub> than is in the atmosphere. This property is used, for example, in greenhouse crops. By artificially increasing CO<sub>2</sub> concentration, you can obtain more abundant crops.

*Fun Fact 2*

Joseph Priestley  
13.03.1733–6.02.1804

He was an English chemist, philosopher and clergyman. He discovered oxygen, ammonia, carbon monoxide, hydrogen chloride, and sulfuric acid.

You can find more about photosynthesis here:

<https://www.nature.com/scitable/topicpage/photosynthetic-cells-14025371/>

This material is important for understanding the essence of the exercise.

## PERFORMING THE EXERCISE

### Exercise B07:

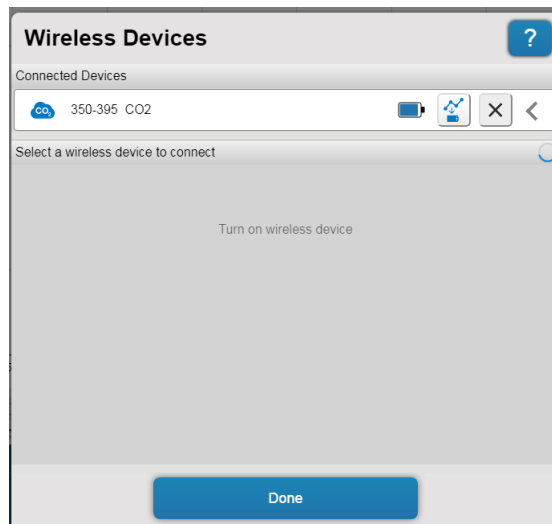
### Measurement of changes in CO<sub>2</sub> concentration - Photosynthesis

EQUIPMENT	
• PC with „SPARKvue”	• Cloth to darken the layout
• Sensor CO <sub>2</sub> - PASCO wireless CO <sub>2</sub>	• Pestle
• Transparent bootle	• Leaves, e.g. spinach
• Light sources (e.g. flashlights)	• Good mood

Record all observations, data, explanations and answers in a table and study.

Prepare the computer - do not save files changes h (DON'T SAVE)

1. Turn on the table's power supply (see the table's dashboard - next to your left leg when you are sitting in front of the computer) - turn the red "knob" in the direction of the arrows (it should pop out), turn the key like in a car and let go. Turn on the computer.
2. The *Windows* operating system will start automatically. Log in by pressing user icon **B07**. Power on the sensor: PASCO wireless CO<sub>2</sub>. The sensor turns off when not in use. In the middle of the desktop there is a shortcut B07 - it launches the "SPARKvue" program along with the file supporting the exercise - run it! Expand the window to full screen.
3. Tap the Bluetooth icon (upper right corner of the window). Connect the CO<sub>2</sub> sensor (350-395 CO<sub>2</sub>) by clicking it in the devices window. Once added correctly, click "Done". The correct connection of the sensors is shown in the photo below. **Do not connect other sensors!**



### Sensor calibration PASCO wireless CO<sub>2</sub>. (350-395 CO<sub>2</sub>).

1. Press the "CO<sub>2</sub> Concentration" bar (bottom left corner of the "SPARKvue" window).
2. Choose „Calibrate measurement”.
3. Press the button „Calibrate” (do not change other settings). A message will appear that the sensor has been calibrated to 400 ppm CO<sub>2</sub>. This is the typical concentration of carbon dioxide in the atmosphere.
4. Confirm „Ok”.

### Experiment window B07

Basic window "CO<sub>2</sub> - light condition" - contains control buttons, a graph of the CO<sub>2</sub> concentration (ppm) versus time. The ranges on the axes will change automatically during measurements.



## Preparation of the measuring system

1. Holding the sampling bottle horizontally, place three fresh leaves into the bottle. The leaves should lie flat and overlap as little as possible. Use tweezers to arrange the leaves. If they have long tails, tear them off.
2. Close the sampling bottle with the carbon dioxide sensor and stopper. Place the bottle on its side on a flat surface.



The photo shows a properly prepared measuring system.

## The course and recording of measurements

### Dark phase

1. Cover the entire system so that the leaves in the bottle are in the dark.
2. Wait 5 minutes to stabilize the measurement conditions.
3. Press the "Start" button (when data collection is active, a red square is displayed and the time is counted down). The measurement will last 7 minutes.
4. After, the measurement stops automatically, continue as follows instructions below.



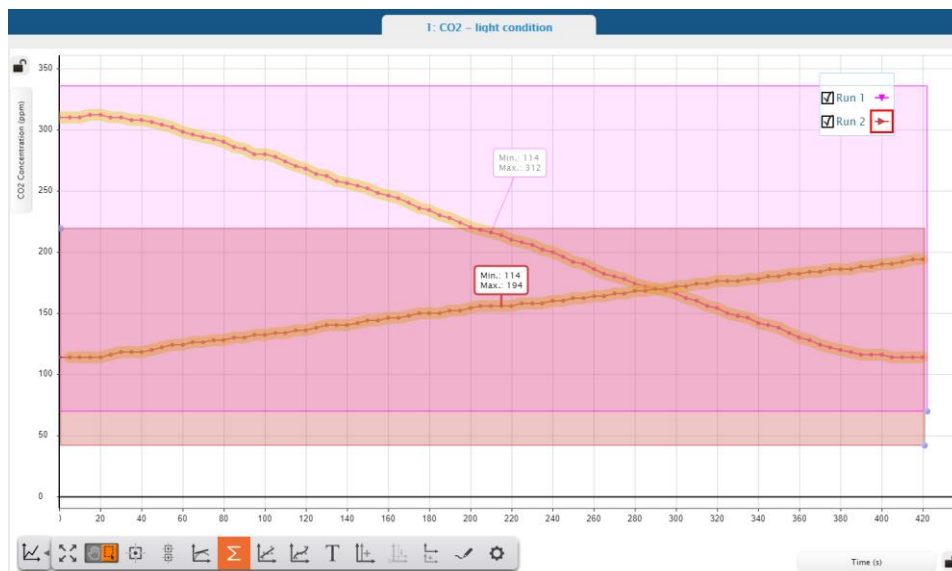
### Light phase

1. Turn on the flashlight (the first press of the switch activates maximum illumination, only take measurements in this setting). Choose the light color with the instructor. Cover the entire arrangement so that the leaves in the bottle are illuminated by the light from the flashlight.
2. Wait 5 minutes to stabilize the measurement conditions.
3. Press the "Start" button (when data collection is active, a red square is displayed and the time is counted down). The measurement will last 7 minutes.
4. After the measurement stops automatically, repeat the experiments in the order "Dark phase", "Light phase".



## Data analysis – assessment of concentration changes of CO<sub>2</sub>

1. Use the "Scale to fit" button to fit the received data to the windows.
2. Select the data to analyze. Use the button „Toggle move/Select mode”.
3. Now press the  $\Sigma$  button to display the statistics options. Select "Minimum" and "Maximum" and confirm by pressing "Ok".
4. Perform steps 2 and 3 for each measurement. Calculate the changes in CO<sub>2</sub> concentration for each case and record the results in the table. To calculate the change in CO<sub>2</sub> concentration, subtract the final CO<sub>2</sub> concentration from the initial CO<sub>2</sub> concentration. These are the Min and Max values. Appropriately. Record the results as absolute values.
5. The print screen below shows an example analysis.

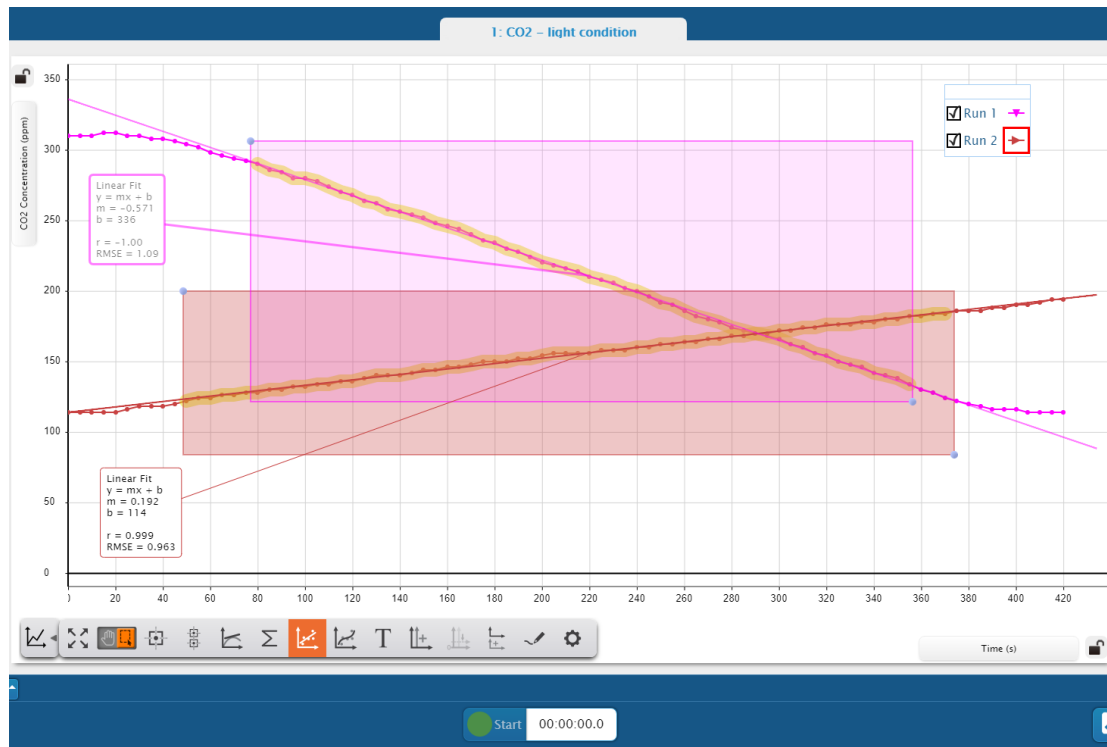


6. In the next step, remove the statistics and selected data fields. To do this, click on the statistics box. An "X" button will appear. Pressing will delete the statistic. Similarly, select the checkbox and delete it.

## Data analysis – rate of change in CO<sub>2</sub> concentration

1. To assess the rate of change in CO<sub>2</sub> concentration under given conditions, linear functions should be fitted to individual data series. To do this, select the "Show/hide linear fit" button.
2. The slope of the line ( $m$ ) is the rate of change CO<sub>2</sub> concentration.
3. Select data to analyze that is linear. Use the "Toggle move/Select mode" button. When choosing a data range, try to keep the correlation coefficient ( $r$ ) close to 1.
4. To control the course of the analysis, we recommend working on one data series. Checking or unchecking the "tick" next to e.g. "Run 1" will display or hide the data series.

5. Write the obtained data in a table.
6. The print screen below shows an example analysis.



Questions for discussion:

1. What does the (-) or (+) sign mean when the rate of CO<sub>2</sub> concentration changes.
2. What are slope coefficients?