# MJSO

Malta Junior Science Olympiad

2025

**GOVERNMENT OF MALTA**
MINISTRY FOR EDUCATION, SPORT, YOUTH
RESEARCH AND INNOVATION
DIRECTORATE FOR STEM & VET PROGRAMMES

# Acknowledgements

The tasks included in this booklet are the result of a team effort and reflect the contributions of Ms Penelope Fitzgerald (EO Biology), Mr Michael Mercieca (EO Chemistry), and Ms Audrey Vella Bondin (EO Physics).

Extended thanks go to Mr Jonathan Azzopardi (Lead Technician) and his team of laboratory technicians for the laboratory equipment organisation and preparation.

Much appreciation go to Mr Jonathan Portanier Mifsud (Head of School) for hosting the event at St Benedict College Kirkop Secondary School.

Special thanks go to Mr Michael Mercieca (EO Chemistry) for the design and compilation of this booklet.


# Instructions

- SAFETY FIRST – wearing a lab coat together with safety specs is mandatory at all times. Long hair must be kept tied.
- It is important that all laboratory equipment is handled carefully. In case of any breakages, report immediately to the lab supervisor.
- Each team is requested to clean the lab station adequately after handing in the script to the lab supervisor.
- You are asked to attempt all questions and to write your answers clearly in the spaces provided.
- You are also reminded of the necessity of good English and orderly presentation of your answers.
- Use of electronic calculators is permitted.

# Section A: Biology

1) Chromatography is a method used to separate mixtures into their different parts. It is especially useful for breaking down solutions to see what they're made of. Scientists use chromatography because it is a simple and accurate way to separate complex substances.

   Chromatography is also used to separate the pigments found in plants. Plants which are green have chlorophyll pigments but also other hidden pigments in their leaves. Other plants have other pigments which gives the leaves red, pink, orange or purple colours.

   When we look at a plant, the colour we see is the light (wavelength range) that is reflected. The colours we don't see are the ones the plant absorbs and uses for energy. The pigments in the plant help it capture sunlight, which is then used in photosynthesis — the process plants use to make their own food.

**Safety procedure:**
The solvent in this investigation is volatile and flammable. Apparatus must be cleaned; any solvent must be disposed of through running water and solvent container well closed before the **chemistry investigation** is attempted!

**Investigation:**
To compare the types of photosynthetic pigments present in two different leaves using paper chromatography.

**Apparatus and materials:**
2 boiling tubes, boiling tubes rack, strips of chromatography paper, solvent, pipette, 2 beakers - one containing leaves A and the other leaves B, pestle and mortar, sand.

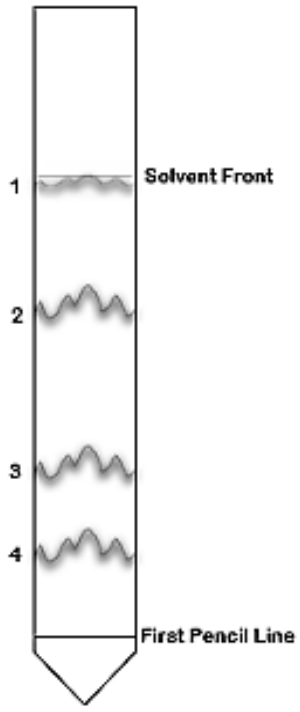

**Figure 1**

**Method:**
1. Take a strip of chromatography paper.
2. With a pencil lightly make a line at about 1.5 cm of one end of the paper (as in Figure 1).
3. Bend the strip of paper at the top end. Adjust the length of the paper so that when it is inserted into the boiling tube, it will touch the bottom without curling. Remove the chromatography paper from the boiling tube.
4. Prepare the solution by putting leaves A, a very small amount of solvent and some sand in the mortar. Use the pestle to break open the cells of the leaves so that the leaf pigments dissolve in the solvent. Put a small but viscous drop of this solution

on the pencil line. Leave to dry for a few minutes. If the drop is not dark in colour repeat the above by putting more drops on the initial drop. Allow to dry between one drop and another.

5. Using the pipette, dispense a small amount of chromatography solvent in the boiling tube. This should be less in length than 1.5 cm.
6. Carefully lower the paper strip into the test tube. The solvent must touch the end of the paper but should not touch the pencil line.
7. Be careful not to slosh the solvent. Allow the tube to stand undisturbed.
8. Observe the solvent movement, pigment movement and the band separation (if any).
9. When the solvent has moved approximately half the distance of the paper lift the chromatography paper from the test tube. Mark the edge of the solvent front with a pencil and carefully outline the pigment with a pencil.
10. Allow the paper to dry completely.
11. Repeat the investigation with leaves B.

Adapted from: https://www.depts.ttu.edu/ciser/science-teacher-resources/traveling-lab/curriculum/plants/Plant_Pigment_Chromatography.pdf

a) Propose a hypothesis that could be tested in this investigation.

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_____

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_____ (2)

b) Describe the importance of the pigments in photosynthesis.

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_____ (2)

c)

i) Stick the two chromatograms in the space below as directed by the lab supervisor. Outline the pigment separation and label each chromatogram appropriately.

Stick your chromatogram here.

(2)

ii) What did you observe on the chromatograms after the two trials?

_____

_____

_____ (2)

iii) Explain, if the results obtained, justify the hypothesis you made.

_____

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_____ (2)

iv) Explain why the base line is drawn in pencil and not in ink.

_____

_____

_____ (2)

v) Give ONE reason why the solvent should not touch the pencil line.

_____

_____ (2)

d) Using the following procedure and the equation given below, work out the $R_f$ values of the pigments on the chromatogram of leaves A.

A chromatogram can be used to identify substances by comparing them with known substances. Two substances are likely to be the same if:

- they produce the same number of spots, and these match in colour.
- the spots travel the same distance as they have the same $R_f$ value.

$R_f$ values can be used to identify unknown chemicals if they can be compared to a range of reference substances. The $R_f$ value for a particular substance is always the same if the same solvent and stationary phase are used.

The $R_f$ equation is the following:

$$R_f = \frac{distance\ travelled\ by\ substance}{distance\ travelled\ by\ solvent}$$

Leaves A - Distance travelled by solvent _____ mm (1)

| | **Leaves A** | | |
|---|---|---|---|
| | Distance travelled by substance (mm) | $R_f$ value | Colour of pigment |
| Pigment 1 | | | |
| Pigment 2 | | | |
| Pigment 3 | | | |
| Pigment 4 | | | |

*Use as many rows as necessary.* (2)

e) Figure 2 shows the absorption spectrum of a number of photosynthetic pigments.

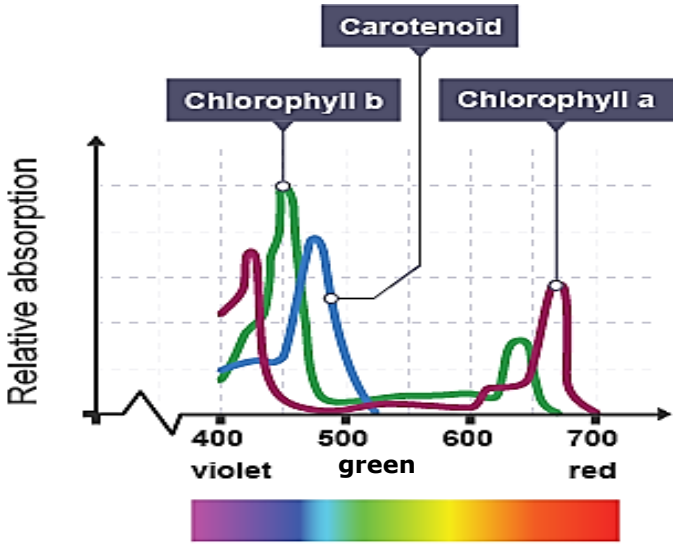


**Figure 2**

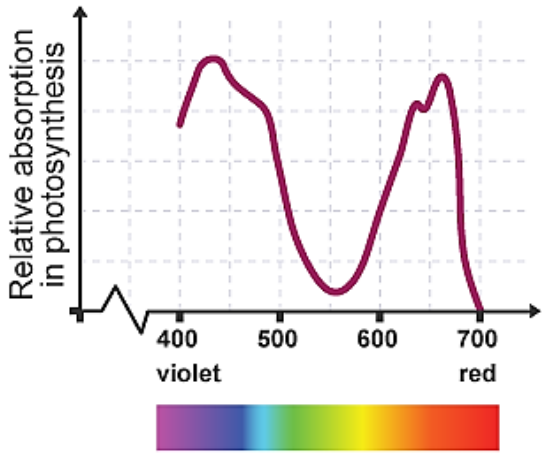


**Figure 3**

*Source: https://www.bbc.co.uk/bitesize/guides/z23ggk7/revision/5*

i) The absorption spectrum shows the wavelength of light absorbed by the pigments. Leaves A contain two type of chlorophyll called chlorophyll A and B. Using Figure 2, explain why leaves A are green.

_____

_____

_____ (2)

ii) Figure 3, the action spectrum, shows how effective the different wavelengths of light are at photosynthesis. The larger the relative absorption in Figure 3, the more photosynthesis occurs. By comparing Figure 2 and Figure 3 together, explain why the action spectrum of photosynthesis closely match the absorption spectrum of chlorophyll, and what does this tell us about the role of chlorophyll in photosynthesis?

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_____ (4)

f) In an investigation on how environmental factors affect the rate of photosynthesis, a group of students set up the apparatus below.

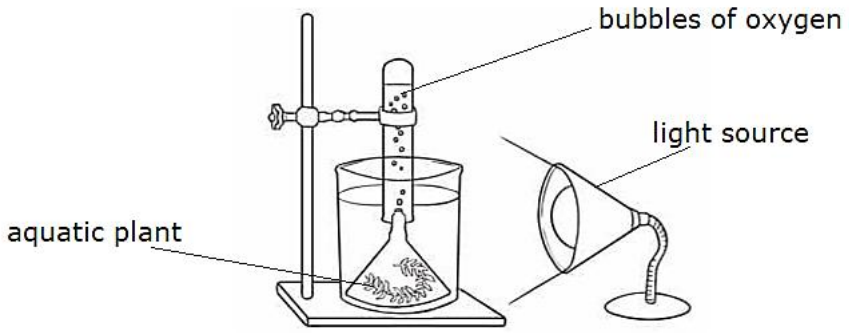


**Figure 4**

*Source: https://www.twinkl.com.mt/resource/light-intensity-photosynthesis-experiment-colouring-t-tp-2677010*

The students put the light source at different distances from the plant and counted the number of oxygen bubbles produced. Oxygen production indicates the rate of photosynthesis. The results obtained are below:

| Distance from light source (cm) | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
|---|---|---|---|---|---|---|---|
| Oxygen production (bubbles per min) | 30 | 22 | 15 | 8 | 4 | 4 | 4 |

i) Draw a graph of oxygen production (bubbles per min) against distance from the light source (cm) on the graph paper on page 8. (5)

ii) Describe the general trend of the graph and interpret these results.

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_____ (2, 2)

iii) Name TWO other factors that limit the plant's ability to photosynthesise.

_____

_____ (2)

**Sub-Total: 34 marks**

# Section B: Chemistry

2) Your task is to produce 0.25 g of dry sodium chloride using the equipment and materials provided below only.

Equipment:

- Tripod
- Wire gauze
- Tongs
- Bunsen burner
- Evaporating basin
- Beaker
- Glass rod
- Measuring cylinder
- Shared: Digital weighing balance + insulating base

Materials:

- 0.5 mol $dm^{-3}$ hydrochloric acid
- 1.0 mol $dm^{-3}$ sodium hydroxide solution
- Distilled water

Make sure that the lab supervisor records the mass of the evaporating basin before starting the experiment and the mass of the evaporating basin including the dry salt at the end of the experiment. Failing to comply incurs a **2-mark penalty**.

a) Write a balanced chemical equation including state symbols for the reaction between hydrochloric acid and sodium hydroxide solution.

_____ (3)

b) Calculate the volume of acid and alkali that need to be mixed together to produce 0.25 g of dry sodium chloride.

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_____ (7)

c) State a property that acids and alkalis share which makes it necessary to use personal protection when handling them.

_____ (1)

d) List TWO health and safety considerations related to your answer in part (c).

_____

_____ (2)

e) Use a numbered list to write the procedure that was used to produce dry sodium chloride from the given solutions.

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_____ (7)

f) Record your results showing all measurements.

(3)

g) List THREE precautions taken to ensure that an accurate result is obtained.

_____

_____

_____ (3)

h) Calculate the percentage yield of sodium chloride in this experiment.

_____

_____

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_____

_____ (5)

i) Give TWO ways how this experiment can be improved.

_____

_____

_____

_____ (2)

**Sub-Total: 33 marks**

# Section C: Physics

3) Resistance in electricity is a measure of how much a material opposes the flow of electric current. It depends on several factors, including the material's properties, its temperature, and its physical dimensions such as length and cross-sectional area.

   In this investigation, you will explore how the resistance of a nichrome wire changes with its length.

   Nichrome, an alloy commonly used in heating elements, has a relatively high and stable resistance, making it ideal for such studies.

   By varying the length of the wire and measuring the resulting resistance, you will determine the relationship between length and resistance, and whether it follows the expected trend described by Ohm's Law.

a) What is the SI unit for resistance?

_____ (1)

**Aim of the investigation:**

To investigate how the length of a wire affects its electrical resistance.

**Apparatus provided:**

Low voltage power supply (use 5V), ammeter, voltmeter, nichrome resistance wire, metre ruler, crocodile clips, and connecting wires.

**ATTENTION:**
**Read ammeter and voltmeter readings quickly to avoid overheating of nichrome wire.**

b) In the space provided draw a diagram of the setup used in your investigation.

(4)

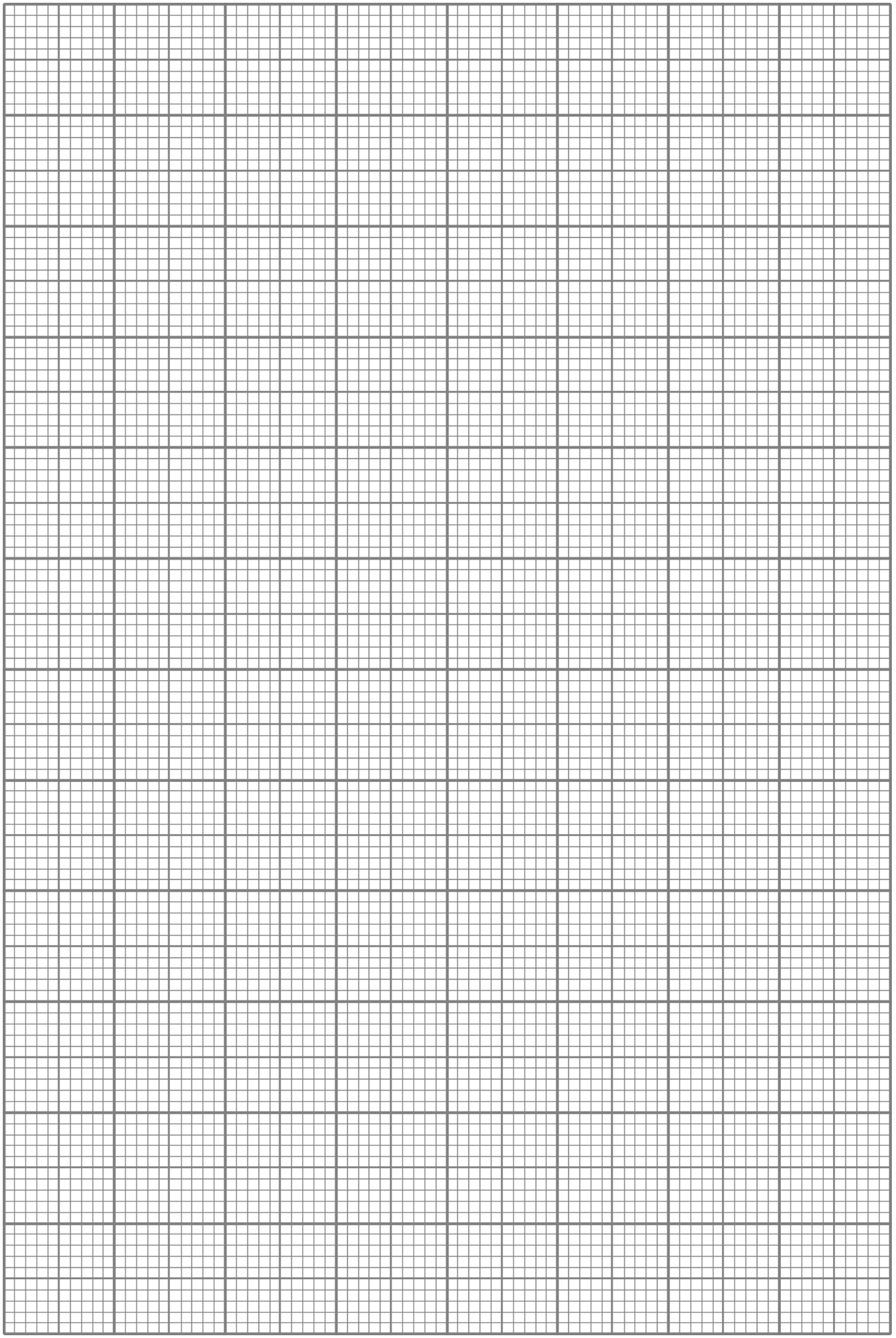
c) Use a numbered list to describe the procedure used in this investigation.

(5)

d) In the space below include a table of the results obtained.

(5)

e) Plot a graph on page 14 of resistance on the y axis against length of nichrome wire on the x axis. (6)



f) Describe the trends in your results.

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_____ (3)

g) How does your data support Ohm's Law?

_____

_____ (2)

h) Mention THREE possible sources of error in this experiment.

_____

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_____ (3)

i) Write a short conclusion for this investigation.

_____

_____ (2)

j) Do you think that copper wire would have been suitable for this investigation? Explain why.

_____ (2)

**Sub-Total: 33 marks**