MJSO

Malta Junior Science Olympiad

2023

SCIENCE CENTRE
PEMBROKE MALTA

Acknowledgements

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

Extended thanks to Ms Adriana Muscat (Senior Technical Officer) and her team of technicians for efficient lab equipment organisation and preparation.

Much appreciation to Mr Michael Vassallo (Head of School) for hosting the event at Maria Regina College, Zokrija Secondary School.

Special thanks are due to Mr Michael Mercieca (EO Chemistry) for the design and compilation of the final booklet.

Instructions

- **SAFETY FIRST** – wearing a lab coat together with safety specs is mandatory at all times. Long hair must be kept tied. Latex gloves must be worn when handling chemicals.
- 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.

Section A: Biology

Organisms contain many different enzymes including the enzyme catalase in their cells. During metabolic activity cells produce the toxic compound hydrogen peroxide. This chemical is a cell damaging agent. The enzyme catalase break downs hydrogen peroxide as shown below:

$$\text{hydrogen peroxide} \xrightarrow{\text{catalase}} \text{water and oxygen}$$

This reduces the damaging effect of this chemical.

Fruits and raw vegetables contain catalase in their cells. Certain fruits and raw vegetables contain more catalase than others. When pieces of the fruits and vegetables are put in hydrogen peroxide bubbling occurs and a foam is produced. The level of foam indicates the concentration of catalase in the cells of the fruit or vegetable.

1) In this investigation you are asked to find the concentration of catalase in the different fruits and vegetables provided.

List of chemicals:
Hydrogen peroxide, slurry of different fruits and vegetables.

List of equipment:
Test tubes, test tube rack, test tube brush, pipette, stopwatch, marker, wooden spoons/spatulas.

Design and conduct an investigation to determine the concentration of catalase in different fruits and vegetables.

Note:

- Hydrogen peroxide dissociates quickly in the presence of light. Use immediately when poured from reagent bottles.
- You are advised to use 5 ml of each solution during the experiment. This is equivalent to 1 cm height in the test tube.

a) Write down the procedure you carried out to determine the concentration of catalase in different fruits and vegetables.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ (6)

b) In such experiments a control can also be used.

i) What is the purpose of an experimental control?

_____

_____ (2)

ii) What control can be used in this investigation and explain the use of this control.

_____

_____ (1, 2)

c) Draw a table of results.

(4)

d) Using the formula:

$$\frac{Average\ height\ of\ froth}{Time\ taken}$$

determine the rate of reaction in cm/min of each fruit and vegetable tested.

(3)

e)

i) Draw a bar chart of the **rate of reaction** against the **fruit and vegetable tested**. Use the graph paper provided on page 5. (6)

ii) Explain why a bar chart and not a line graph should be drawn for this investigation.

_____

_____ (2)

f) Give ONE precaution used and justify the use of this precaution.

_____

_____ (2)

g) The fruits and vegetables given were fresh. State how the rate of reaction would change if old fruits and vegetables were used for this investigation. Give ONE reason for your answer.

_____

_____

_____ (1, 2)

h) If this investigation is set at 30 °C, then the rate of reaction would be higher than the results obtained today. Use your biological knowledge to explain a higher rate of reaction.

_____

_____ (2)

Total: 33 marks

Section B: Chemistry

Qualitative analysis is used to identify unknown substances using a series of chemical tests. The following chemicals and equipment are provided so that you can use them to identify unknown substances, A and B.

List of chemicals
Distilled water, dilute hydrochloric acid, dilute sodium hydroxide solution, acidified silver nitrate solution, aluminium powder, acidified barium chloride solution.

List of equipment
Test tubes, test tube rack, test tube cleaner, spatula, Bunsen burner, nichrome wire, small beaker.

1) For **substance A**:
   a) Provide a description of its colour and appearance.

_____

_____ (2)

   b) Perform a flame test.
      i) Write a description of the method you used.

_____

_____ (2)

      ii) Write your observation/s.

_____ (1)

   c) Use dilute sodium hydroxide solution to determine the cation.
      i) Describe how this test should be carried out.

_____

_____ (2)

      ii) Write your observation/s.

_____ (2)

      iii) Give the ionic equation (omitting spectator ions) for the reaction.

_____ (2)

   d) There are several tests which can determine the anion. For the test that yields a positive result.
      i) Describe how this test was carried out.

_____

_____ (2)

ii) Write your observation/s.

_____ (1)

iii) Give the ionic equation (omitting spectator ions) for the reaction.

_____ (2)

e) From your observations, identify substance A.

_____ (2)

2) For **substance B**:

a) Provide a description of its colour and appearance.

_____

_____ (2)

b) Perform a flame test and write your observation/s.

_____ (1)

c) Use dilute sodium hydroxide solution to determine the cation.

i) Write your observation/s.

_____ (2)

ii) Give the ionic equation (omitting spectator ions) for the reaction.

_____ (3)

d) There are several tests which can determine the anion. For the test that yields a positive result.

i) Describe how this test was carried out.

_____

_____ (2)

ii) Write your observation/s.

_____ (1)

iii) Give the ionic equation (omitting spectator ions) for the reaction.

_____ (2)

e) From your observations, identify substance B.

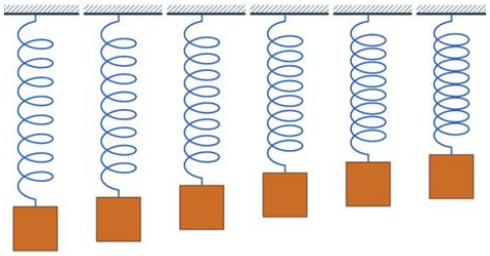
_____ (2)

Total: 33 marks

Section C: Physics

1) **Simple Harmonic Motion in a Spring-Mass System**

Many things in nature are periodic. These periodic events occur in repeated cycles. You are requested to investigate the periodic motion of a spring.



Basic physics will allow you to determine the Hooke's Law spring constant. Your analysis will also yield the effective mass of the spring, a factor that is important in real-world engineering applications.

Some concepts and terms which underlie this investigation are:

Spring, Hooke's law, spring constant, oscillation, period, or periodic time.

a)

i) State Hooke's law.

_____

_____ (2)

ii) Define periodic time (period).

_____ (1)

You are provided with the following apparatus:

- Retort stand with spring attached.
- 50 g masses.
- Stop clock.

You are requested to follow the instructions below:

1. Before starting the experiment make sure that the spring is attached to the retort stand and that it is not moving.
2. Having no mass attached to the spring, stretch one end of the spring in your hand and release it to allow the spring to bounce up and down.
3. Count the number of cycles the spring makes in 60 s with no mass hanging from it and perform at least three trials.
4. Hang one 50 g mass from the spring, stretch one end of the spring in your hand and release it to allow the spring to bounce up and down.
5. Count the number of cycles the spring goes through in 60 s with the 50 g mass attached and perform at least three trials for this mass.
6. Repeat steps 4 and 5, each time increasing the mass by 50 g.

b) Enter your results in Table 1 in the space provided below:

Table 1:

(4)

The spring obeys Hooke's law. This can be represented by the equation:

Equation 1:

$$F = -kx$$

- F is the restoring force in newtons (N)
- k is the spring constant in newtons per meter (N/m)
- x is the displacement from equilibrium in meters (m)

When you add a weight to a spring, stretch it and then release it, the spring will oscillate before it returns to rest at its equilibrium position. This system is called a simple harmonic oscillator.

In this investigation, you will determine how adding more mass to the spring changes the period, T, and then graph this data to determine the spring constant, k, and the equivalent mass, m_e, of the spring.

Equation 2 relates period to mass, M:

Equation 2:

$$M = k\frac{T^2}{4\pi^2}$$

- M is the load on the spring in kilograms (kg)
- K is the spring constant in Newtons/meter (N/m)
- T is the period in seconds (sec)

In an ideal spring-mass system, the load on the spring would just be the added weight. But real springs contribute some of their own weight to the load. That is why the spring bounces even when there is no weight added. So, the equation can be modified to look like this:

Equation 3:

$$M = m + m_e = k\frac{T^2}{4\pi^2}$$

In this equation, the total mass pulling down on the spring is comprised of two masses, the added weight, m, plus a fraction of the mass of the spring, which we will call the mass equivalent of the spring, m_e. Rearranging Equation 3 will give you the form of the equation which you will use later for graphing, so:

Equation 4:

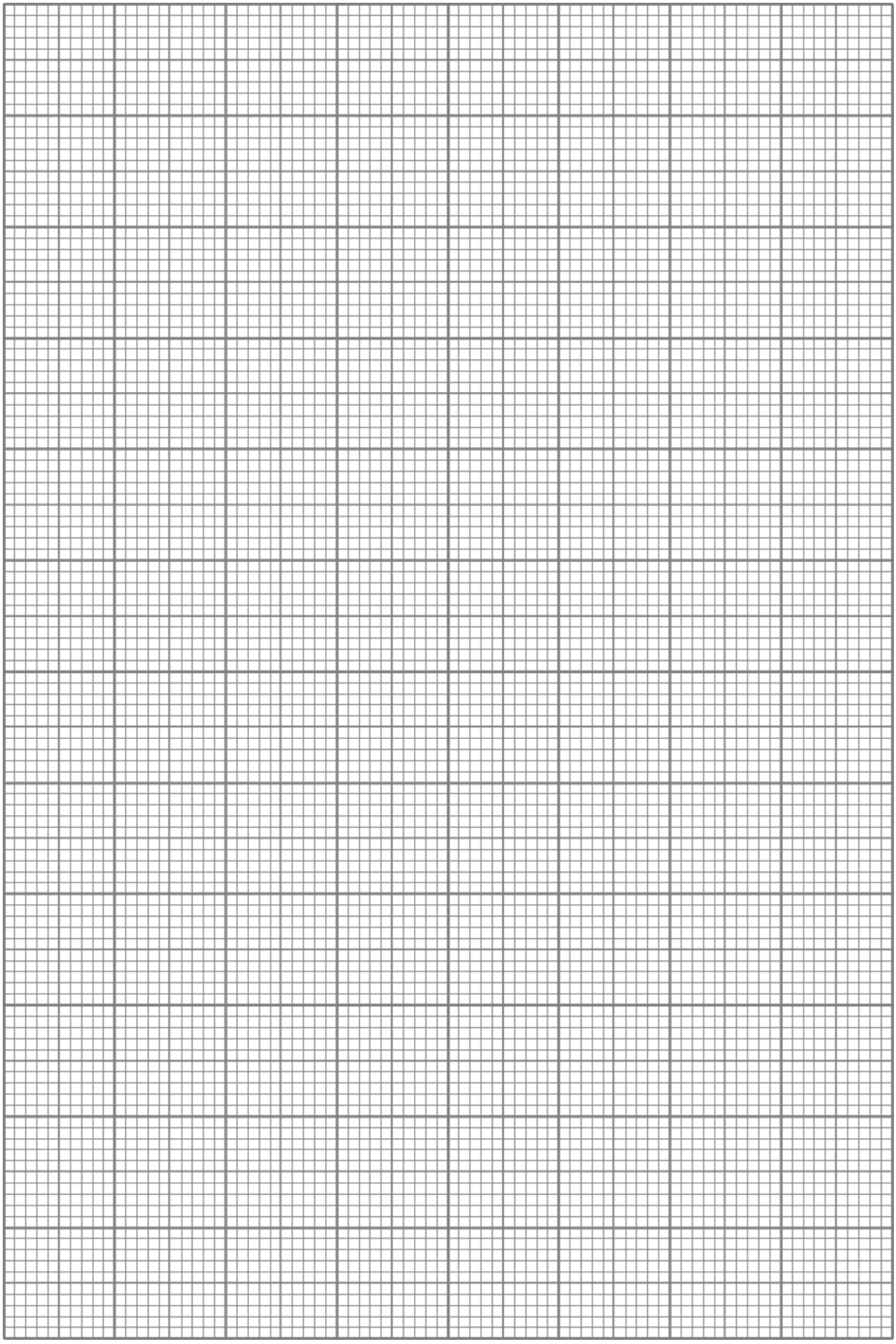
$$m = k\frac{T^2}{4\pi^2} - m_e$$

c) Fill in Table 2 below to convert your raw data into numbers that can be used to determine the spring constant and spring's effective mass. (6)

Table 2:

A	B	C	D	E
Added mass (kg)	**Average cycles in 60 s (cycles/min)**	**F, frequency (Hz)**	**T, periodic time of the spring (s)**	**$T^2/4\pi^2$ (s^2)**

d) Plot a graph of **Added mass, m**, in kilograms on the y axis against $T^2/4\pi^2$ in s^2 on the x axis. Use the graph paper provided on page 11. (6)



e) From the graph find the spring constant, k.

_____

_____

_____ (3)

f) Use the graph to find the mass of the spring, m_e.

_____

_____

_____ (3)

g) Indicate any anomalous point/s in the graph.

_____ (1)

h) How does adding mass change the period of a spring?

_____

_____ (2)

i) Would a stiffer spring have a shorter or longer period than a less stiff spring with the same mass?

_____

_____ (2)

j) Excluding the periodic motion of a spring as an example, give four other real-world examples of simple harmonic oscillators.

_____

_____

_____ (4)

Total: 34 marks

End of paper