Acknowledgements

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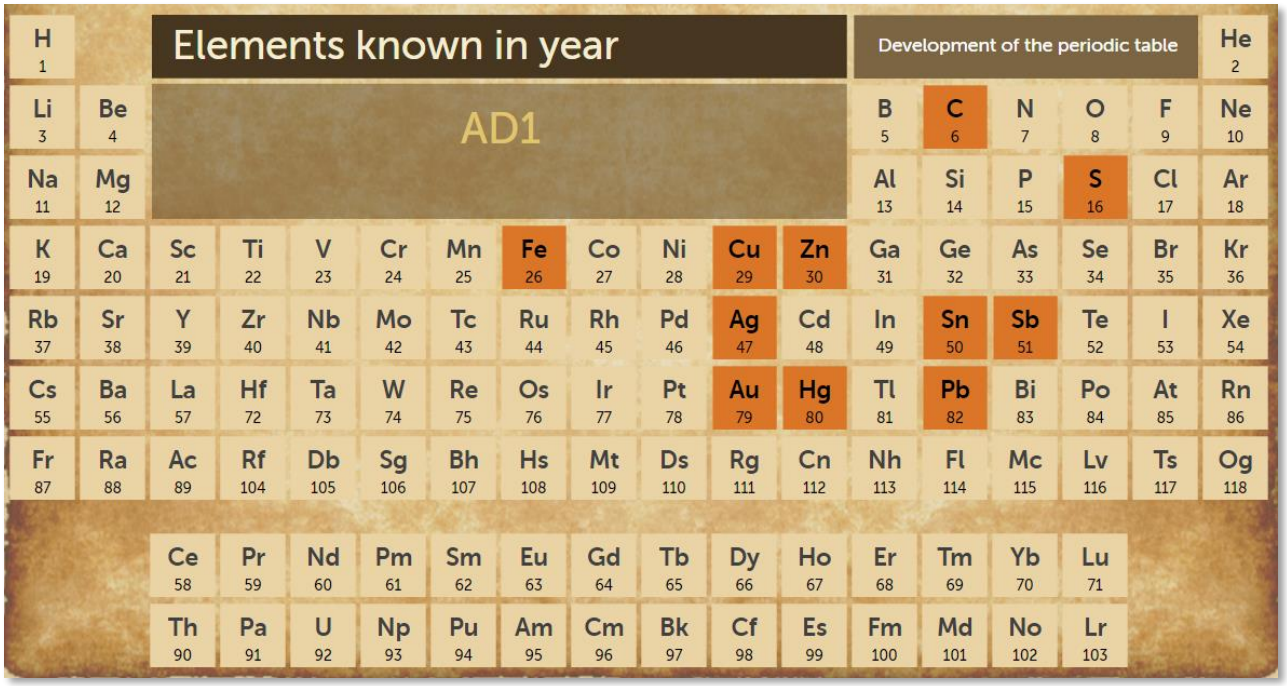
Instructions

- **SAFETY FIRST** – wearing a lab coat together with safety specs is mandatory at all times.
- You are asked to attempt all questions and to write your answers clearly in the spaces provided. Any work scribbled in the 'Rough Work' space will **not** be considered.
- Each team is requested to clean the lab station adequately after handing in the script to the lab supervisor.
- It is important that all laboratory equipment is handled carefully. In case of any breakages report immediately to the lab supervisor.
- You are also reminded of the necessity of good English and orderly presentation of your answers.

Introduction

Elements are substances that cannot be split into other substances. They are the building blocks of all other substances that exist in the universe! Only few elements have been known since ancient times (circa 5000 years BC). These include carbon, sulfur, gold, and copper. By the year 1 AD few of the elements were known as one can see from the picture of the periodic table below:

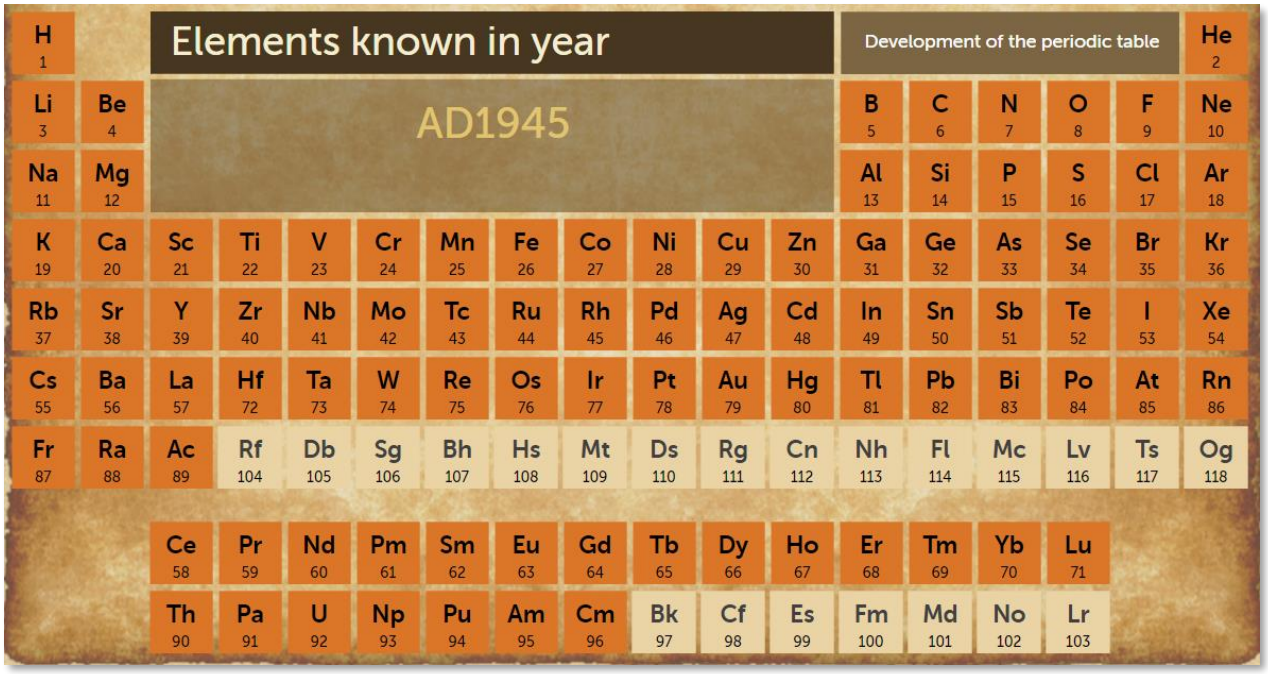


Source: http://www.rsc.org/periodic-table/history

This situation did not improve much for many years to come. In fact, by the year AD 1736, only three other elements were discovered.

Source: http://www.rsc.org/periodic-table/history

However, by AD 1945, that is by the end of World War 2, all the naturally occurring elements were discovered by scientists.



Source: http://www.rsc.org/periodic-table/history

By AD 2010, the rest of the elements up to element 118 (Oganesson) were synthesized in laboratories by colliding smaller elements to produce larger elements that are not found naturally.

Source: http://www.rsc.org/periodic-table/history

Currently, research is underway to discover the possibility of synthesizing elements beyond Oganesson.

It is important to know what matter is made of since most elements have properties that are useful to us. Furthermore, understanding the nature of matter provides chemists/scientists the opportunity to create new materials that not necessarily exist in nature. Scientists are also in a position to produce naturally occurring materials synthetically for example vanillin and insulin among many other materials.

The table of elements is called a Periodic Table of Elements and was first proposed by Dimitry Mendeleev in 1869. In the Periodic Table of Elements, elements are not only placed in order of increasing atomic number, but they are also grouped according to similar chemical properties. The year 2019 has been assigned as the International Year of the Periodic Table of the Elements by UNESCO to commemorate 150 years since Mendeleev proposed the idea of the periodic table.

Investigation

The element oxygen is a by-product of the biological process photosynthesis. Earth's atmosphere contains about 21 % by volume oxygen which is attributed to the effect of photosynthesis. The aim of this investigation is to determine the rate of photosynthesis. One measure of the rate of photosynthesis is through the amount of oxygen produced during photosynthesis.

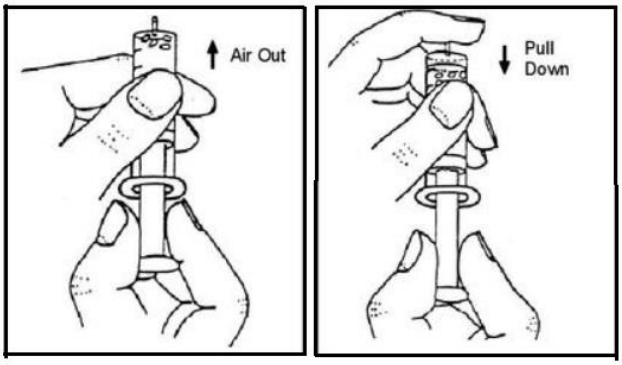
a) This investigation involves leaf discs floating when their buoyancy increases as the air spaces inside the leaf fill up with oxygen. Leaf discs normally float. When the air spaces in the leaf become filled with sodium hydrogen carbonate solution, the overall density decreases, and the leaves sink. Sodium hydrogen carbonate is a carbon source for photosynthesis while light provides the energy needed for this reaction.

Materials

Sodium hydrogen carbonate solution, 10 ml syringe, glass straw, 50 ml beakers, stopwatch, light source, clamp, spinach leaves.

In this investigation, you need to remove air from the air spaces in the leaf before initiating the experiment. The procedure is the following:

1. Cut leaf discs from the leaf provided.
2. Place the leaf discs in the syringe by removing the plunger from the syringe barrel.
3. Replace the plunger. Do NOT crush the leaves.
4. Push the plunger until a small volume of air remains in the barrel.
5. Siphon a small volume of hydrogen carbonate solution into the syringe. Tap the syringe to suspend the leaf discs in the solution. Remove the excess air by pushing the plunger until fluid comes out of nozzle.



https://www.stem.org.uk/resources/elibrary/resource/28162/investigating-factors-affecting-photosynthesis-using-leaf-discs

6. Holding a finger at the syringe nozzle, pull the plunger to create a partial vacuum. Hold for some seconds and release the plunger back. Check if leaf discs sink to the bottom. Repeat until all discs sink to the bottom of syringe.
7. Remove the plunger and pour the discs and solution in the beaker. You are now ready to start your investigation.

Design an experiment to investigate the rate of photosynthesis at TWO different light intensities.

Experimental suggestions:

- Light intensity varies with the depth of liquid and height of the lamp from the leaves.
- Use at least 10 leaf discs.
- At the end of each minute, record the number of floating discs.
- From time to time, swirl the beaker slowly to dislodge leaf discs stuck to the sides of the beaker.
- The mark on the clamp rod indicates the maximum height to be investigated.

Your report should include:

i) A hypothesis of the investigation.

(2)

ii) The procedure carried out for this investigation.

(4)

iii) TWO constant variables in this investigation.

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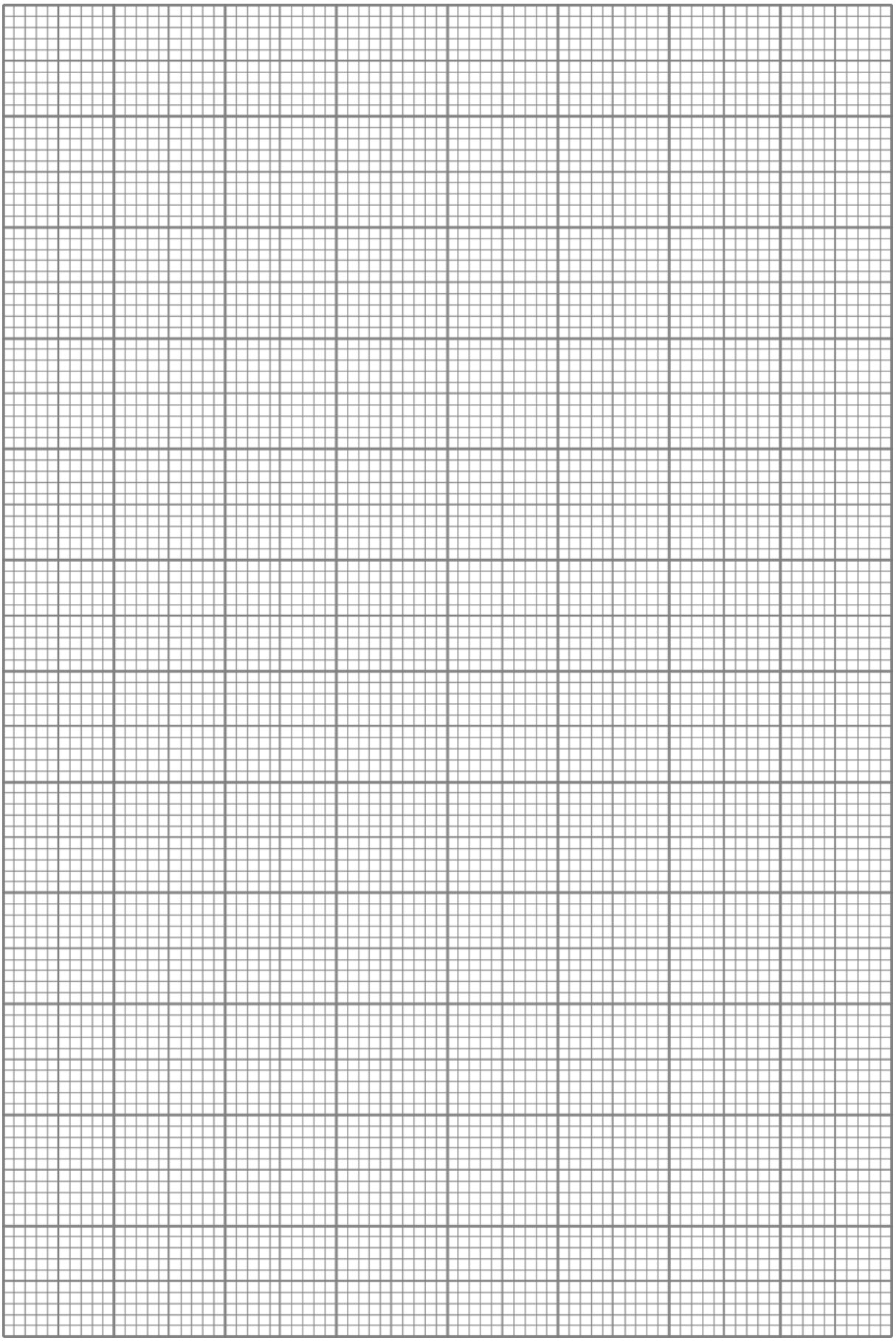
_____ (2)

iv) A table of results including the number of floating discs per minute for the two different light intensities.

(4)

v) Two line graphs on the same graph paper showing the number of floating discs against time in minutes for **each** light intensity.



(5)

vi) The calculation of the rate of photosynthesis for **each** light intensity using the following steps:

1. From the graph, for **each** light intensity, find the time at which 50 % of the leaf discs are floating. This is the ET_{50}. (Show this value on your graph)
2. Using the formula, Rate of photosynthesis = $1/ET_{50}$, find the rate of photosynthesis at **each** light intensity. (Show your working).

(3)

vii) A balanced chemical reaction including state symbols for the reaction where the hydrogen carbonate solution produces carbon dioxide.

_____ (3)

viii) An interpretation of the results obtained.

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_____ (2)

ix) A biological explanation of the results obtained.

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_____ (3)

x) ONE source of error of this investigation.

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_____ (1)

xi) The conclusion from the results obtained.

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_____ (1)

b)

i) Explain, in terms of forces, why the individual leaf discs experience a buoyant force which makes them rise to the surface.

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_____ (2)

ii) Describe what would happen to the floating leaf discs if they were left in the dark and explain why these changes occur.

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_____ (1, 2)

iii) The rate of photosynthesis is considered as the net rate of photosynthesis and is not a value of the rate at the light intensity investigated. Explain.

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_____ (3)

c) Oxygen can also be produced in the laboratory using hydrogen peroxide. The aim of this experiment is to determine the effect of surface area of an organic catalyst on the rate of oxygen produced.

Safety First!

You will be using 30 vol hydrogen peroxide which is a dangerous substance. Take note of the following hazard pictograms and statements.

Signal Word **Danger**

Hazard Statements

H272 - May intensify fire; oxidizer
H302 - Harmful if swallowed
H318 - Causes serious eye damage

Precautionary Statements

P280 - Wear protective gloves/ protective clothing/ eye protection/ face protection
P210 - Keep away from heat/sparks/open flames/hot surfaces. - No smoking
P221 - Take any precaution to avoid mixing with combustibles
P301 + P330 + P331 - IF SWALLOWED: rinse mouth. Do NOT induce vomiting
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P310 - Immediately call a POISON CENTER or doctor/ physician

Source: ThermoFisher Scientific (Revision Date: 2019, Revision #: 16)

In addition to wearing a lab coat and safety glasses, make sure to wear latex gloves at all times during this part of the investigation.

Design and carry out an experiment to investigate the effect of surface area on the rate of oxygen production using the equipment and materials provided.

Conical flask with sidearm, rubber bung, rubber tubing, rubber bands, stopwatch, plastic trough, 35 vol hydrogen peroxide solution, gas jar, gas jar cover, a potato, beehive shelf, digital weighing balance (one per lab), a knife.

Note the following points:

- Use 10 g of potato for **each** round of your experiment.
- The experiment starts when oxygen begins to collect in the gas jar.
- Take readings every minute.
- Record the first 8 readings.

Your report should include:

i) A hypothesis of the investigation.

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_____ (2)

ii) A balanced chemical equation including state symbols for the reaction that produces oxygen.

_____ (3)

iii) The experimental procedure followed.

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_____ (4)

iv) TWO precautions related to the experiment.

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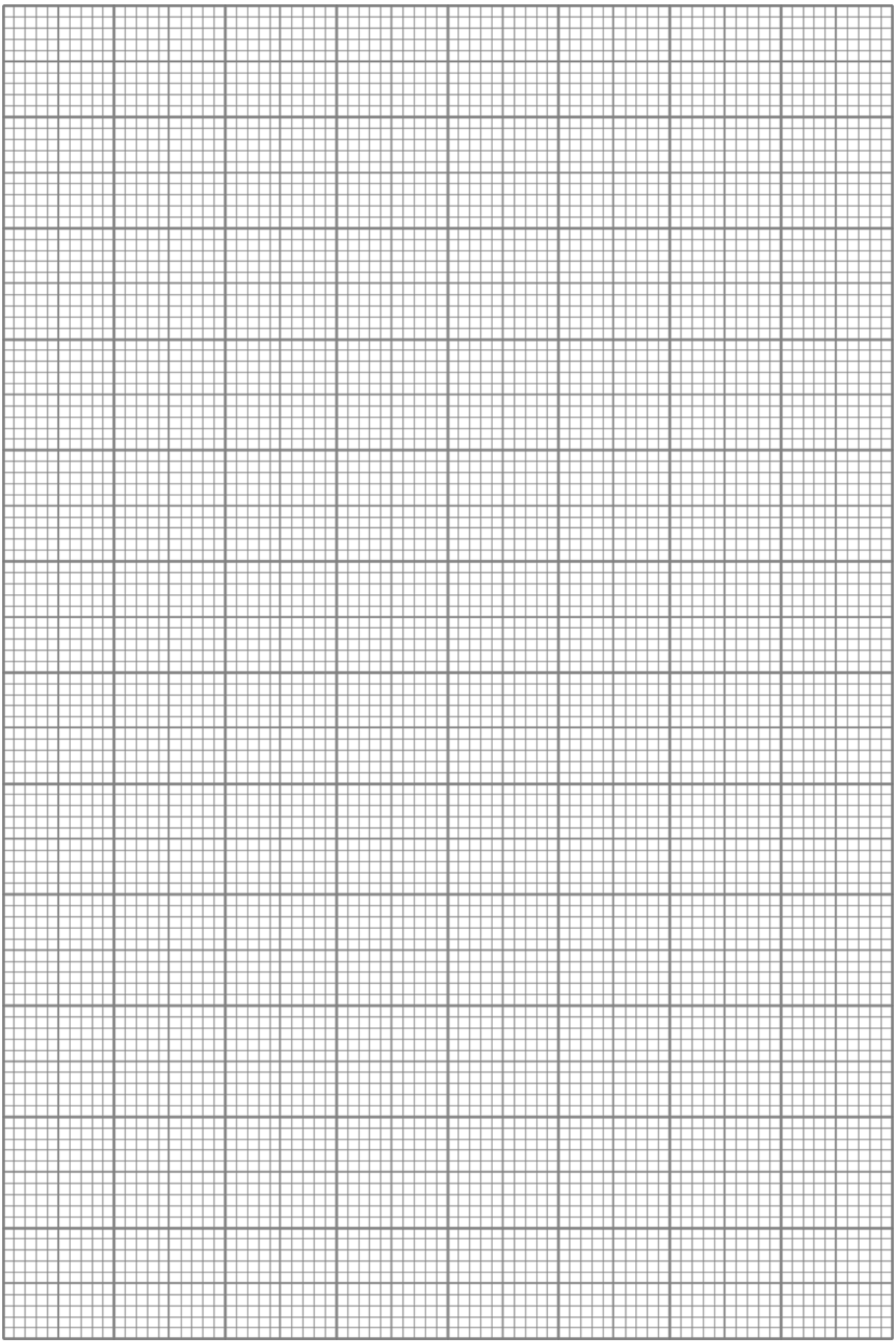
_____ (2)

v) A table of results.

(5)

vi) A line graph of the volume of oxygen (cm^3) against time (minutes).



(5)

vii) The measurement of the rate of reaction at the midpoint of the slowest reaction.

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_____ (2)

viii) ONE variable that is kept constant during the experiment.

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_____ (1)

ix) TWO sources of error.

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_____ (2)

x) The conclusion from the obtained results.

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_____ (3)

Density is a fundamental property of matter. Each element has a characteristic density that can be used to facilitate its identification.

d) Calculate the theoretical value for the density of oxygen in grams / litre at room temperature and pressure. (RAM of oxygen = 16, molar volume of any gas at RTP = 24 dm^3)

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_____ (2)

Carbon is element number six in the periodic table of the elements. It is a non-metal and has two allotropes, namely diamond and graphite. Normally, non-metals do not conduct electricity. However, graphite conducts electricity.

e)

i) With reference to the bonding in graphite, explain why graphite is a conductor of electricity.

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_____ (1)

The 'lead' in pencil, contrary to its name, is predominantly made up of a combination of graphite and clay, with wax and other additives in small quantities. Clay, unlike graphite, is an insulator.

The shade of pencil is dependent on the percentage of each component as shown below:

Hardness	9H	8H	7H	6H	5H	4H	3H	2H	H	F	HB	B	2B	3B	4B	5B	6B	7B	8B	9B
Carbon (%)	41	44	47	50	52	55	58	60	63	66	68	71	74	76	79	82	84	87	90	93
Clay (%)	53	50	47	45	42	39	36	34	31	28	26	23	20	18	15	12	10	7	5	2

Source:
https://www.google.com/search?q=snr_physics_07_sai_electric_conduct_graphite.pdf&rlz=1C1GCEU_enMT820MT820&oq=snr_physics_07_sai_electric_conduct_graphite.pdf&aqs=chro

ii) Write a hypothesis to indicate how the grade of a drawing pencil in HB scale affects the electrical conductivity of the pencil.

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_____ (2)

Using the apparatus provided, perform an experiment to explore the relationship between grade of pencil on HB scale and its conductivity.

Power supply, connecting wires, timer, multimeter, pencils (B, 2B, 3B, 4B, 5B, and 6B).

You are requested to follow the instructions below:

1. Measure the length of the graphite cylinder in one of the pencils.
2. Connect the ends of the pencil to crocodile clips and leads to the power supply.
3. Connect the multimeter to measure the current passing through the pencil.
4. Set the power supply to 4V to generate a current through the circuit. Set the timer for a 10-second countdown and the multimeter dial on the 200mA setting.
5. Note the value of the current from the multimeter after 10 seconds have elapsed.
6. Repeat steps 4 -5 to get 5 readings from which to determine the mean value of current.
7. Repeat steps 1-6 for all the pencils which have been provided.

IMPORTANT: Switch off the power supply when the circuit is not in use.

iii) In the space below draw a circuit diagram of the experimental setup.

(1)

iv) Give ONE reason why current is allowed to pass through **each** of the pencils for only 10 seconds.

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_____ (2)

v) Fill in the table of results below with the values obtained during the experiment.

Grade of pencil	Graphite cylinder length, l, (m)	Trial 1 Current value (A)	Trial 2 Current value (A)	Trial 3 Current value (A)	Trial 4 Current value (A)	Trial 5 Current value (A)	Mean Current value (A)
B							
2B							
3B							
4B							
5B							
6B							

(6)

For a graphite cylinder with length, l (m), cross-sectional area, A (m^2) and resistivity, ρ (Ω m), connected to a DC supply, its resistance is given by:

$$R = \frac{\rho \times l}{A}$$

Electrical conductivity, which is denoted by the symbol, σ, has SI units of siemens per metre (S/m) and is the inverse of resistivity, ρ.

Replacing resistivity (ρ) with electrical conductivity, σ:

$$R = \frac{l}{\sigma \times A}$$

Isolating σ:

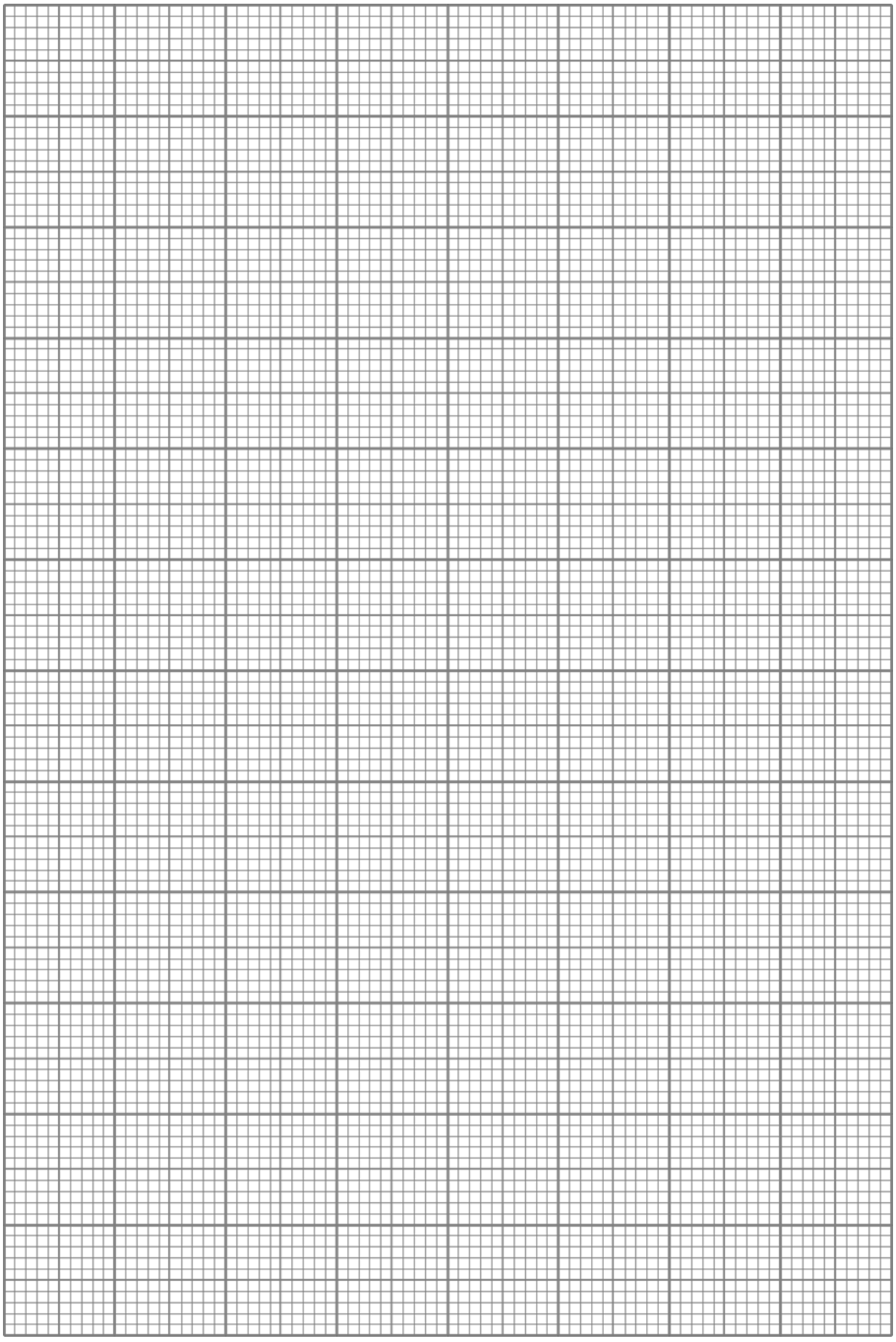
$$\sigma = \frac{l}{R \times A}$$

vi) With the information provided, calculate the electrical conductivity of **each** of the pencils.

Note: The diameter of each graphite cylinder in each pencil is 2.86 mm. Show your calculations in the space below:

(6)

vii) On the graph paper below, plot a bar graph to graphically represent the electrical conductivity of each pencil.



(5)

viii) Explain the observed trends and draw a conclusion from this experiment.

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_____ (2)

ix) Using your conclusion in part (viii), give an industrial application for the use of carbon in the form of graphite.

_____ (1)

x) List TWO controlled variables in this experiment.

_____

_____ (2)

xi) State TWO possible sources of error in this experiment.

_____

_____ (2)

xii) If you are asked to redesign this experiment, list ONE improvement that you would make to the experimental design.

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_____ (1)