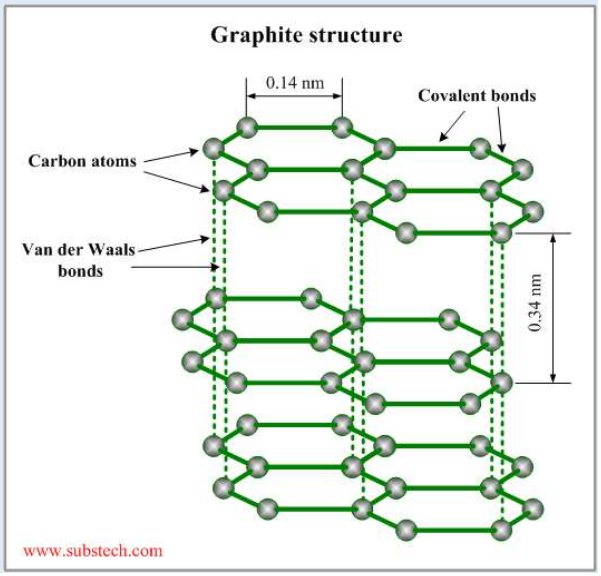
Student's Card 1 **Electrochemistry lab experiences with CRMs**

Module 1

Objective: Electrolysis of water and graphite conductivity

Introduction

Graphite, which can be found naturally, is the most stable form of carbon under standard conditions. It consists in a crystalline form of the element carbon with its atoms arranged in layers of hexagonal structure by means of covalent bonds (three of the C valence electrons are involved). Forces between each layer (called graphene) are weak, so they can slide over each other. This is due to the fourth valence electron which is left un-bonded, and thus is able to move freely. Therefore, the delocalized electrons are free to move through the structure, so graphite can conduct electricity, making it useful for electrodes in batteries and for electrolysis.



Necessities

Reagents	Formula		Quantity (g) or Concentration (M)
Water	H_2O		500 g
Common Salt	NaCl		50 g

List of materials/tools

- Plastic container (you can recycle one that you already have, size around 10 x 15 cm)
- 2 carpenter pencils (sharpen them so pencil lead is in both sides)
- Sharpener
- Silicone gun
- 2 test tubes
- Battery (4.5 V)
- 3 cables with alligator clip wires

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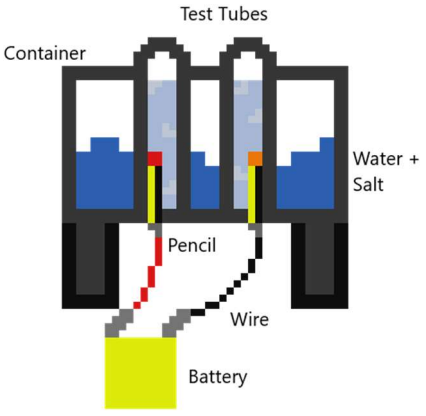
- 3 pencils of different hardness (e.g. 2H, HB and 2B)
- Multimeter

Lab Procedure

Aim: To develop or modify an electrical circuit by using graphite

- First, create the structure where we will perform the experiment, making two holes at the bottom of the container, the size that carpenter pencils pass through them.
- Take the silicone gun and stick the pencils to the holes (try to cover the best you can the space left, to avoid the water from licking out of the container). The pencils need to be half inside the container and the other half outside of it.
- Pour the water into the container, add the salt and stir until it dissolves.
- Take a test tube, fill it with the water of the container and put it vertical and backwards, so a pencil is inside it. Do the same with the other test tube. To prevent water from licking out of the tube while you are putting it backwards, try to put the entrance of the tube inside of the water as fast as you can. Once it is inside the water will not go out.
- Strip the cable´s ends until you remove the insulation.
- Put one side of the cable around the graphite and the other side around one of the two parts of the battery (positive or negative side). Proceed in the same way with the other cable.
- After connecting the second cable with the battery the circuit will be closed and the electrolysis will begin.



Now that we have proved that graphite is a good electricity conductor, it is possible to measure its conductivity using Ohm's law.

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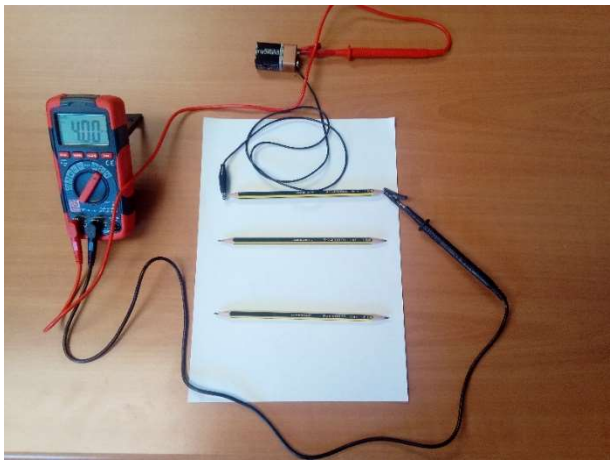

Aim: To investigate how the percentage of graphite in pencil "lead" influences its electrical resistance

Add a sharpener, a multimeter, alligator clip wires and three pencils of different hardness (2H, HB and 2B). The experimental procedure would consist in:

- Use the pencil sharpener to sharpen both ends of the pencils.
- Take a wire and attach one end to one terminal of the battery and the other to the pencil lead portion, using the alligator clips. Make sure the clips are attached to the graphite and not to the wood because it is an insulator material and thus do not conduct electricity.
- Connect the multimeter by clipping the alligator wires to the other free battery terminal and pencil lead, making sure that the circuit is closed.
- Use the multimeter to measure both, the current and voltage and record the results in a table.
- Repeat the process with the two remaining pencils.
- Once you have all the results in a table, use the Ohm's Law and its formula to calculate the electrical resistance. Compare the values between the three pencils and draw a conclusion.

Calculations

Calculate the resistance of each pencil applying Ohm´s equation. Use the current and voltage measured with the multimeter for each pencil.

$$R = \frac{V}{I}$$

R = resistance (Ω), V= voltage (V) and I = current (A)

Questions/Quiz

Q1) Which is the reaction related with the electrolysis?

Q2) Why the water in the test tubes went down slowly?

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Q3) Identify which gas is formed in the anode and which one in the cathode during the electrolysis.

Q4) Write the three reactions that happen in the process: oxidation, reduction and net reaction during the electrolysis.

Q5) Complete the table and draw your conclusions.

Pencil	Graphite (%)	Current (A)	Voltage (V)	Resistance (Ω)

Table 2: *Percentage values of the mass amount of graphite, clay, and wax particles for the entire range of pencil grades based on information received from pencil manufacturers.*

Pencil Number	Graphite	Clay	Wax
9H	0.41	0.53	0.05
8H	0.44	0.50	0.05
7H	0.47	0.47	0.05
6H	0.50	0.45	0.05
5H	0.52	0.42	0.05
4H	0.55	0.39	0.05
3H	0.58	0.36	0.05
2H	0.60	0.34	0.05
H	0.63	0.31	0.05
F	0.66	0.28	0.05
HB	0.68	0.26	0.05
B	0.71	0.23	0.05
2B	0.74	0.20	0.05
3B	0.76	0.18	0.05
4B	0.79	0.15	0.05
5B	0.82	0.12	0.05
6B	0.84	0.10	0.05
7B	0.87	0.73	0.05
8B	0.90	0.04	0.05

Sousa and Buchanan (2000), Models of pencils materials

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