Name…….. **Code** ……..



Experimental Test

December 8th, 2022

Name……. **Code** …….

EXAMINATION RULES

1. You are NOT allowed to bring any personal items into the examination room, except for the water bottle, personal medicine or approved personal medical equipment.

2. You must sit at your designated desk.

3. Check the stationery items (pen, calculator, and scrap paper) provided by the organizers.

4. Do NOT start answering the questions before the “START” signal.

5. You are NOT allowed to leave the examination room during the examination except in an emergency in which case you will be accompanied by a supervisor/volunteer/invigilator.

6. If you need to visit the bathroom, please raise your hand.

7. Do NOT disturb other competitors. If you need any assistance, raise your hand and wait for a supervisor to come.

8. Do NOT discuss the examination questions. You must stay at your desk until the end of the examination time, even if you have finished the exam.

9. At the end of the examination time you will hear the “STOP” signal. Do NOT write anything more on the answer sheet after this stop signal. Arrange the exam, answer sheets, and the stationary items (pen, calculator, and scrap paper) neatly on your desk. Do not leave the room before all the answer sheets have been collected.

Name…….. **Code** ……..

EXAM INSTRUCTIONS

1. After the “START” signal, you will have 4 hours to complete the exam.

2. ONLY use the pen,pencil and other equipment provided by the organizers.

3. Check if your name, code and country name are filled in your sheets..

4. You have 60 pages of the exam sheet containing 5 questions – including the front page. Raise your hand, if you find any sheets missing.

5. Read the problems carefully and write the correct answers in the corresponding spaces after each question in this document.

6. This paper will be evaluated. Before writing your answers you may use the scrap paper provided to avoid errors on your paper.

7. The number of points that can be obtained is indicated for each question.

9. Useful information for answering the questions is provided on page 4.

10. Always show your calculations. If you do not show your calculations, no points are awarded for the question.

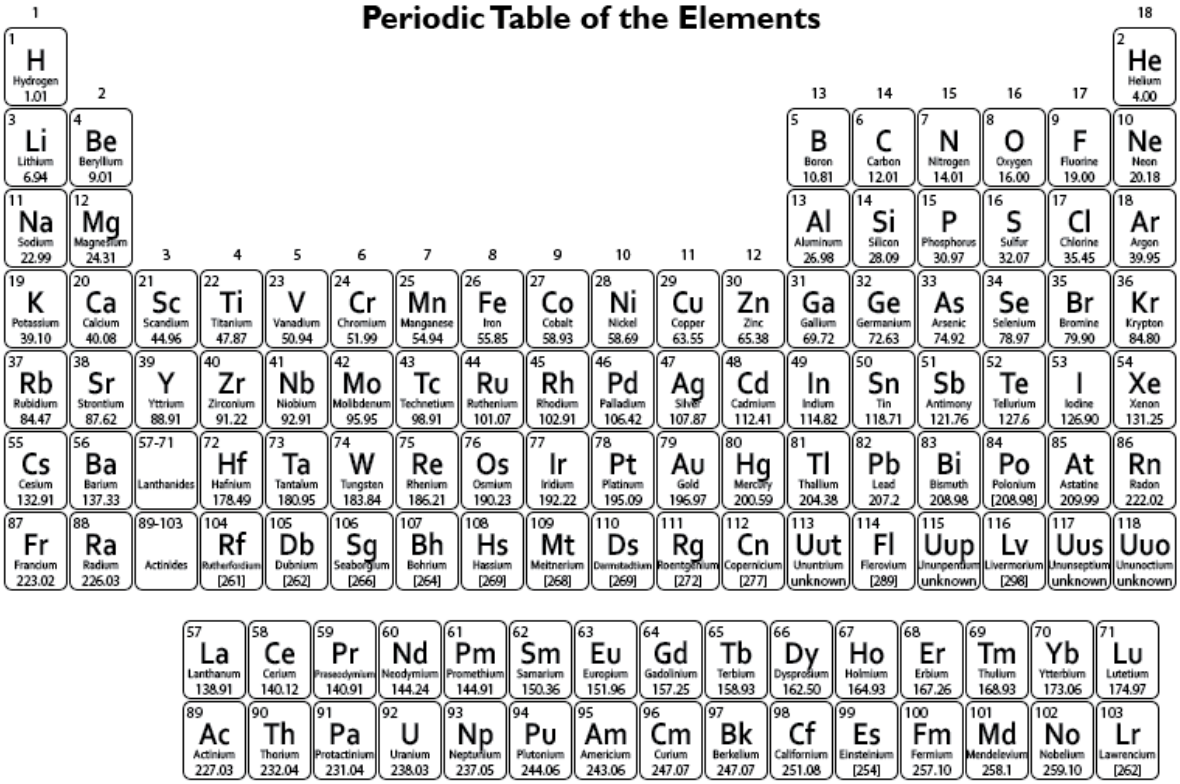
11. You should write your final answers down in the appropriate number of digits.

Name…….. **Code** ……..

GENERAL INFORMATION

constant	
Acceleration due to gravity	$g = 9.81\ m/s^2$
Universal gas constant	$R = 8.314\ \frac{J}{mol \cdot K}$
	$R = 0.08206\ L \cdot atm/mol \cdot K$
Refractive index of air	$n = 1$
Avogadro's constant	$N_A = 6.022 \times 10^{23}\ mol^{-1}$
Speed of light	$c = 2.998 \times 10^8\ m/s$
Planck's constant	$h = 6.626 \times 10^{-34}\ J \cdot s$
Specific heat capacity of water	$c_w = 4.18\ kJ/kg \cdot °C$

Name……. **Code** …….


Periodic Table of the Elements
1 H Hydrogen 1.01
2 He Helium 4.00
3 Li Lithium 6.94
4 Be Beryllium 9.01
5 B Boron 10.81
6 C Carbon 12.01
7 N Nitrogen 14.01
8 O Oxygen 16.00
9 F Fluorine 19.00
10 Ne Neon 20.18
11 Na Sodium 22.99
12 Mg Magnesium 24.31
13 Al Aluminum 26.98
14 Si Silicon 28.09
15 P Phosphorus 30.97
16 S Sulfur 32.07
17 Cl Chlorine 35.45
18 Ar Argon 39.95
19 K Potassium 39.10
20 Ca Calcium 40.08
21 Sc Scandium 44.96
22 Ti Titanium 47.87
23 V Vanadium 50.94
24 Cr Chromium 51.99
25 Mn Manganese 54.94
26 Fe Iron 55.85
27 Co Cobalt 58.93
28 Ni Nickel 58.69
29 Cu Copper 63.55
30 Zn Zinc 65.38
31 Ga Gallium 69.72
32 Ge Germanium 72.63
33 As Arsenic 74.92
34 Se Selenium 78.97
35 Br Bromine 79.90
36 Kr Krypton 84.80
37 Rb Rubidium 84.47
38 Sr Strontium 87.62
39 Y Yttrium 88.91
40 Zr Zirconium 91.22
41 Nb Niobium 92.91
42 Mo Molibdenum 95.95
43 Tc Technetium 98.91
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.91
46 Pd Palladium 106.42
47 Ag Silver 107.87
48 Cd Cadmium 112.41
49 In Indium 114.82
50 Sn Tin 118.71
51 Sb Antimony 121.76
52 Te Tellurium 127.6
53 I Iodine 126.90
54 Xe Xenon 131.25
55 Cs Cesium 132.91
56 Ba Barium 137.33
57-71 Lanthanides
72 Hf Hafnium 178.49
73 Ta Tantalum 180.95
74 W Tungsten 183.84
75 Re Rhenium 186.21
76 Os Osmium 190.23
77 Ir Iridium 192.22
78 Pt Platinum 195.09
79 Au Gold 196.97
80 Hg Mercury 200.59
81 Tl Thallium 204.38
82 Pb Lead 207.2
83 Bi Bismuth 208.98
84 Po Polonium [208.98]
85 At Astatine 209.99
86 Rn Radon 222.02
87 Fr Francium 223.02
88 Ra Radium 226.03
89-103 Actinides
104 Rf Rutherfordium [261]
105 Db Dubnium [262]
106 Sg Seaborgium [266]
107 Bh Bohrium [264]
108 Hs Hassium [269]
109 Mt Meitnerium [268]
110 Ds Darmstadtium [269]
111 Rg Roentgenium [272]
112 Cn Copernicium [277]
113 Uut Ununtrium unknown
114 Fl Flerovium [289]
115 Uup Ununpentium unknown
116 Lv Livermorium [298]
117 Uus Ununseptium unknown
118 Uuo Ununoctium unknown
57 La Lanthanum 138.91
58 Ce Cerium 140.12
59 Pr Praseodymium 140.91
60 Nd Neodymium 144.24
61 Pm Promethium 144.91
62 Sm Samarium 150.36
63 Eu Europium 151.96
64 Gd Gadolinium 157.25
65 Tb Terbium 158.93
66 Dy Dysprosium 162.50
67 Ho Holmium 164.93
68 Er Erbium 167.26
69 Tm Thulium 168.93
70 Yb Ytterbium 173.06
71 Lu Lutetium 174.97
89 Ac Actinium 227.03
90 Th Thorium 232.04
91 Pa Protactinium 231.04
92 U Uranium 238.03
93 Np Neptunium 237.05
94 Pu Plutonium 244.06
95 Am Americium 243.06
96 Cm Curium 247.07
97 Bk Berkelium 247.07
98 Cf Californium 251.08
99 Es Einsteinium [254]
100 Fm Fermium 257.10
101 Md Mendelevium 258.1
102 No Nobelium 259.10
103 Lr Lawrencium [262]

Name…….. **Code** ……..

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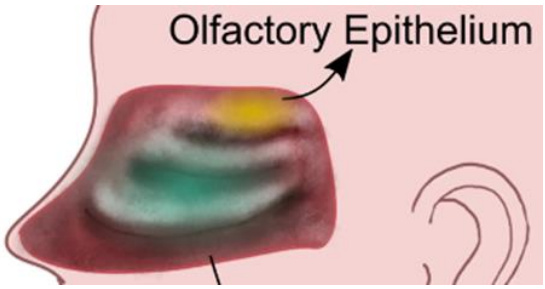
This Experimental paper is composed of the following sections:

- **Experiment 1 Electronic model of the olfactory sensor neuron** **pg 6**
- **Experiment 2 Measuring Resistivity** **pg 15**
- **Experiment 3 The viscosity of Cerebrospinal fluids** **pg 26**
- **Experiment 4 The effect of pH on Anthocyanins** **pg 42**
- **Experiment 5 Determining the species of Coffee** **pg 49**

EXPERIMENT 1: ELECTRONIC MODEL OF OLFACTORY SENSORY NEURONS

The smell is the faculty or power of perceiving odors or scents by means of the organs in the nose. In many animals from different phylums, this process involves a special and sophisticated tissue localized in the roof of the nasal cavity called olfactory epithelium (Fig 1.1).

The main cell during smell perception is the olfactory sensory neuron (OSN, green in Fig 1.2), which has a particular bipolar morphology, with a knob going inside of the nasal cavity protruding many cilia in contact with the mucus.



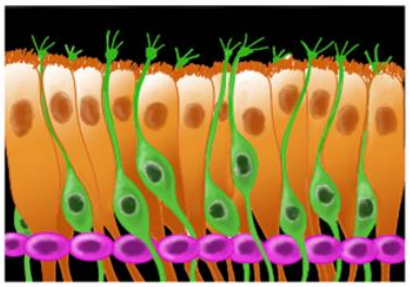


Figure 1.1. Nasal cavity Figure 1.2. Olfactory epithelium

Every cell has a potential difference (voltage) across the cell membrane. In neuro-electrical experiments it is defined that the exterior of the cell has a potential equal to zero. When there is no signal from outside of the cilia, no odorants in the nose, the voltage across the membrane is constant and negative.

The cilia membrane (Figure 1.3) is the place where the odorants bind to its protein receptor (R) producing many biochemical reactions in the cytoplasm of the cilia and changing the local membrane voltage. This change occurs because of the opening of ion channels (proteins that allow the membrane to cross ions the membrane) in the membrane. The channels are of two different types:

- cyclic nucleotide-gated channels (CNG) permeable to cations,
- calcium dependent chloride channels (CaCC), which are permeable to chloride.

The voltage across the membranes at both channels becomes less negative than during resting. This change of voltage propagates along the dendrite (III) towards the soma, see Fig 1.4.

In this experiment you will have the opportunity to make a model of olfactory neuron checking the behavior of the voltage at the level of the cilia-knob (II) and in the soma (IV). In Fig 1.4 an equivalent circuit diagram is given of a simplified model of OSN in RESTING.

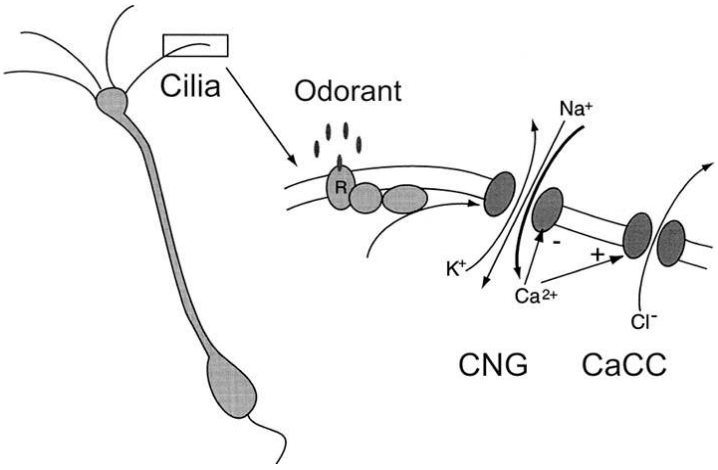


Figure 1.3. Odor binding

Name…….. **Code** ……..

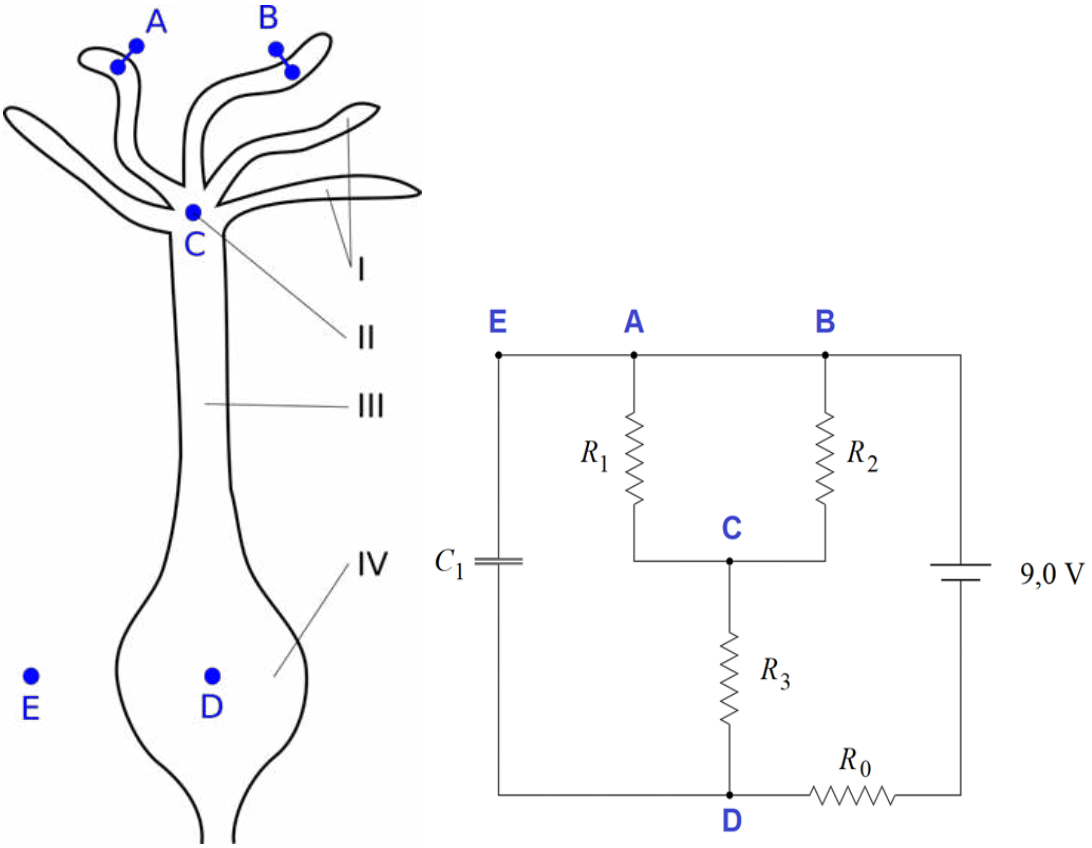


Fig 1.4 On the left: I– cilia, II – cilia-knob, III – dendrite and IV– soma. On the right The corresponding points have been labeled in an equivalent electric circuit of the neuron in RESTING potential.

Here we have a -circuit, a typical model used to describe the passive characteristics of a neuron cell (resistance and capacitance). Parallel resistors represent the channels in the cilia CNG (R1) and CaCCs (R2), internal resistance in the dendrite (R3) and the capacitance (C1), which corresponds to the capability of a material object or device to store electric charge. In this case it can be considered as the cellular membrane of the dendrite tree(III). The resistor of 5.6 MΩ (R0) and 9.0 V battery are auxiliary elements to approximate other physiological values.

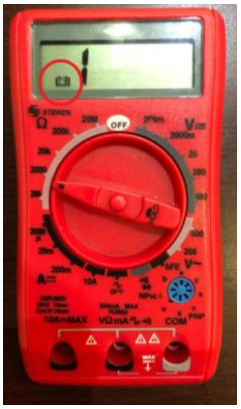
MATERIALS

- 21 electric resistors and 1 electric capacitor in a packet
- 1 battery of 9 V
- Multimeter and cables to used
- Model cell

Name…….. **Code** ……..

Instructions

To add an electronic component in the neuron model, you only have to insert it in the appropriate holes (labeled as in the scheme of the circuit of a neuron in RESTING potential Fig 1.4).

- Plug in the 9.0 V battery to the proper cable, labelled as battery cable.
- Check and select the proper resistors at for the equivalent circuit of a neuron in RESTING potential, with $R_0 = 5.6\ \text{M}\Omega$, $R_1 = 5.1\ \text{k}\Omega$, $R_2 = 5.1\ \text{k}\Omega$ and $R_3 = 4.7\ \text{k}\Omega$. *(these instructions were ommitted from the original paper)*
- Plug in the capacitor (C_1) with unknown value, this remains there for the duration of the experiment.
- If the Multimeter displays the image below raise your hand and request assistance. Do not press the hold button on the centre of the Multimeter
- 

TASK 2

You will change some components of the circuit to model the effect of different odor concentrations. In Table 1, each line represents the state of the neuron under stimulation with different concentrations of **ODOR 1**.

Table 1. Different concentrations of ODOR 1, with the nominal values of for the resistors.

LINE	ODORANT CONCENTRATION (M)	R1 (kΩ)	R2 (kΩ)	R3 (kΩ)
1	1.0×10^{-7}	5.1	5.1	4.7

2	1.0×10^{-6}	4.3	4.7	4.7
3	1.0×10^{-5}	3.9	3.9	4.7
4	1.0×10^{-4}	1.00	2.00	4.7
5	1.0×10^{-3}	0.38	0.54	3.8
6	1.0×10^{-2}	0.38	0.38	3.6
7	1.0×10^{-1}	0.30	0.38	2.0
8	1.0	0.24	0.36	2.0
9	10	0.20	0.36	2.0

Record the measured and nominal values of the resistors in the table below

Nominal resistance (Ohms)	**Measured Resistance (Ohms)**
5.6M	**10% of the nominal value**
47k	
38k	
5.1k	
4.7k	

4.3k	
3.9k	
3.8k	
3.6k	
2.0k	
1.0k	
0.54k	
0.38k	
0.36k	
0.30k	
0.24k	

More than 8 resistors = 0.1

Accurance of the resistors less than 10% = 0.2

(0.2 marks)

Questions

1. Repeat the measurements of the voltages across membranes of the soma and the knob-cilia, as in Task 1, for each line in Table 1. Measure the resistance of the new resistors before you use them. Fill in the table with the measured voltages for both of the cellular compartments. (1.8 marks)

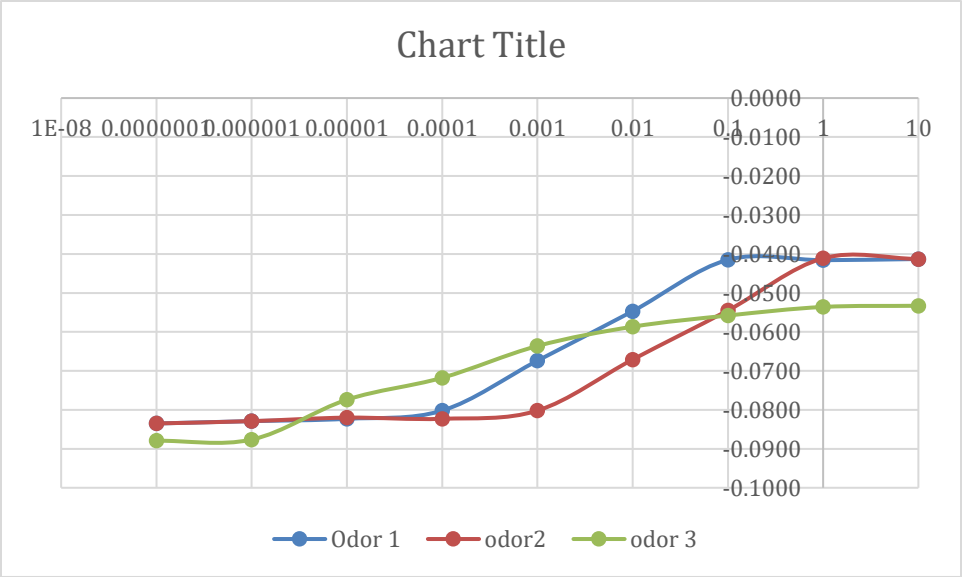
LINE	U_{soma} **(V)**	U_{knoba} **(V)**]
1	-0.0835	0.0792

2	-0.0829	-0.0790
3	-0.0823	-0.0788
4	-0.0802	-0.0790
5	-0.0674	-0.0671
6	-0.0547	-0.0545
7	-0.0415	-0.0411
8	-0.0416	-0.0411
9	-0.0413	-0.0413

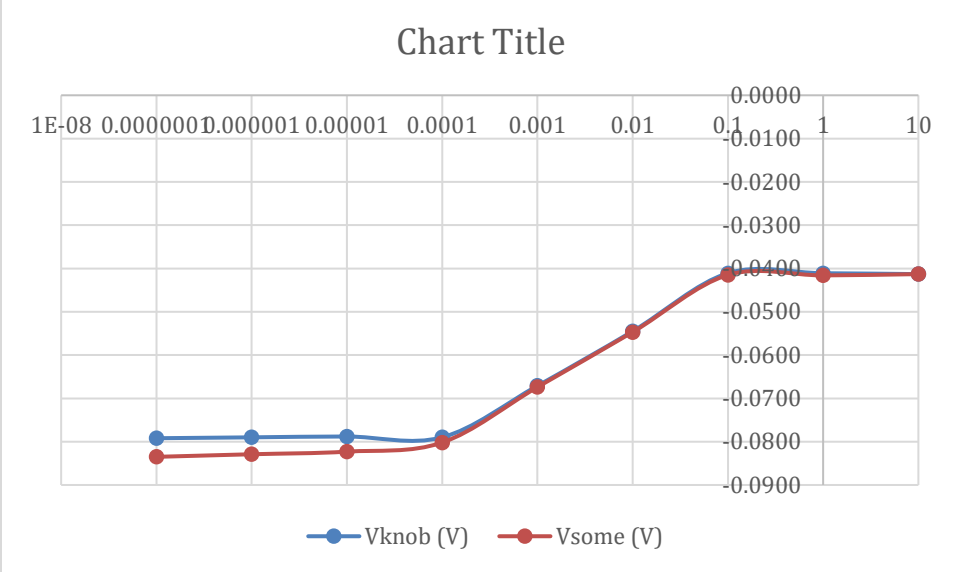
2. Make a plot of U_{soma} as a function of the concentration of odorants: ODOR 1, ODOR 2 and ODOR 3. For the values for ODOR 2 and ODOR 3 use the values from Table 2. Plot the concentration in a logarithmic scale. Table 2. ODOR 2 and ODOR 3. (1 mark)

ODORANT CONCENTRATION (M)	**ODOR 2 (V)**	**ODOR 3 (V)**

1.0×10^{-7}	-0.0835	-0.08793
1.0×10^{-6}	-0.0829	-0.08764
1.0×10^{-5}	-0.0820	-0.0774
1.0×10^{-4}	-0.0823	-0.07178
1.0×10^{-3}	-0.0802	-0.06362
1.0×10^{-2}	-0.0671	-0.05867
1.0×10^{-1}	-0.0545	-0.0558
1.0	-0.0411	-0.0536
10	-0.0413	-0.0533



3. Plot in the same graph U_{soma} and U_{knob} for ODOR 1 as a function of concentration. Plot the concentration in a logarithmic scale (1 mark)



Affinity (α) is defined as a higher response to the same concentration of stimulus.

4. Organize all the 3 odorants according to their affinity value (α_{ODOR1}, α_{ODOR2} and α_{ODOR2}) from the highest to the lowest one. (0.5 marks)

ODOR3-	>	ODOR1-	>	ODOR2

5. Which odorant gives the highest response on the model neuron using stimulation of 10 µM concentration? (0.2 marks)

ODOR 1

6. The absolute value of charge in the capacitor is given by

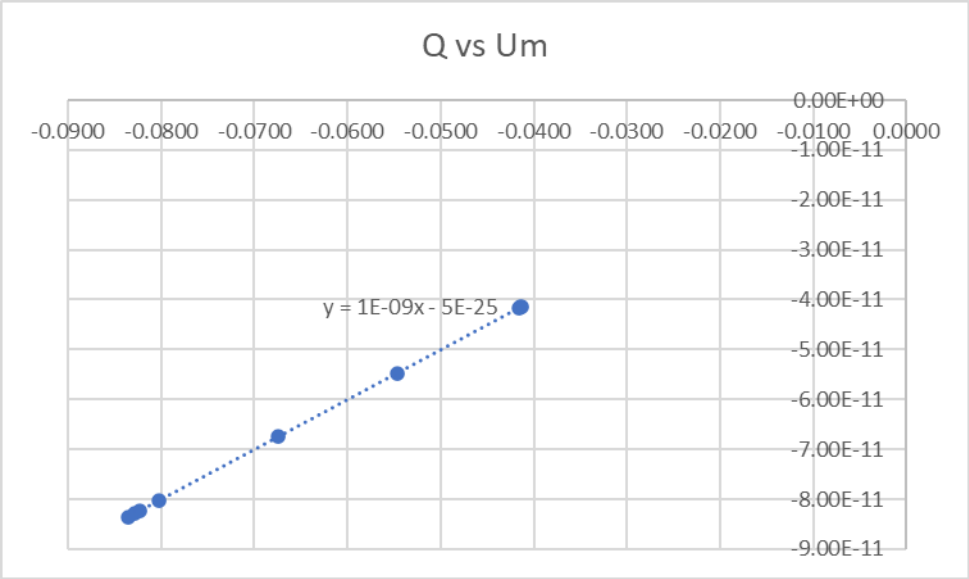
$$Q = C \cdot |U|$$

Table 3 shows the values of charge when our model cell was stimulated with different concentrations of ODOR 1.

Table 3. Charge with stimulated cell

ODORANT CONCENTRATION (M)	**CHARGE (C)**
0.0000001	8.35
0.000001	8.29
0.00001	8.23
0.0001	8.02
0.001	6.74
0.01	5.47
0.1	4.15
1	4.16
10	4.13

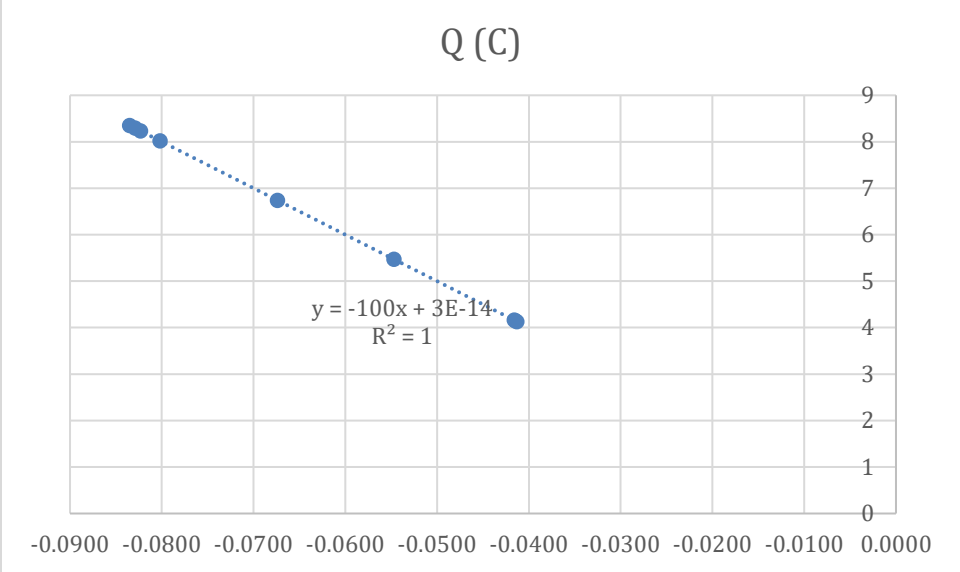
Plot the values of charge as a function of the voltages U-measured already got in question 1 of Task 2 and make a linear regression for the set of data. Deduce from this the value of the capacitance of our cell. (1 mark)



First possibility

Capacitance _____ 1.00E-09

_____ F



Capacitance _____ -100

_____ F

EXPERIMENT 2 MEASURING RESISTIVITY

In this task we will measure the resistivity of a given wire in two different methods.

Part 1 – direct measurement

In this method, we will measure the resistance of different lengths of wire using a multimeter set to resistance measuring mode.

1. For some different lengths of wire, measure their resistance and record your results in the table below: Table 2:1 (0.5 marks)

L[cm]	R[Ω]

10	2.0-2.7
15	2.2 – 3.0
20	2.0 -3.0
25	2.5 – 3.5
30	2.5 – 4.9
35	3.0 – 5.5
40	3.5 – 6.0
45	4.2 -6.8
50	4.0 – 7.5
55	5.0 – 8.5
60	5.0- 8.5
65	6.0 – 9.0
70	6.0 – 9.5
75	7.0 – 10.3

80	6.5 - 10.7

Selected more than 4 values of length and included units = 0.1

Selected a range of more than 10 – 50 cm of length = 0.1

Values within range of mark scheme 0.3 marks for each outside range reduce mark by 0.1 but do not go below zero marks

2. Construct a graph of the resistance of the wire as a function of its length. (1 mark)

Graph preparation (1 marks total)

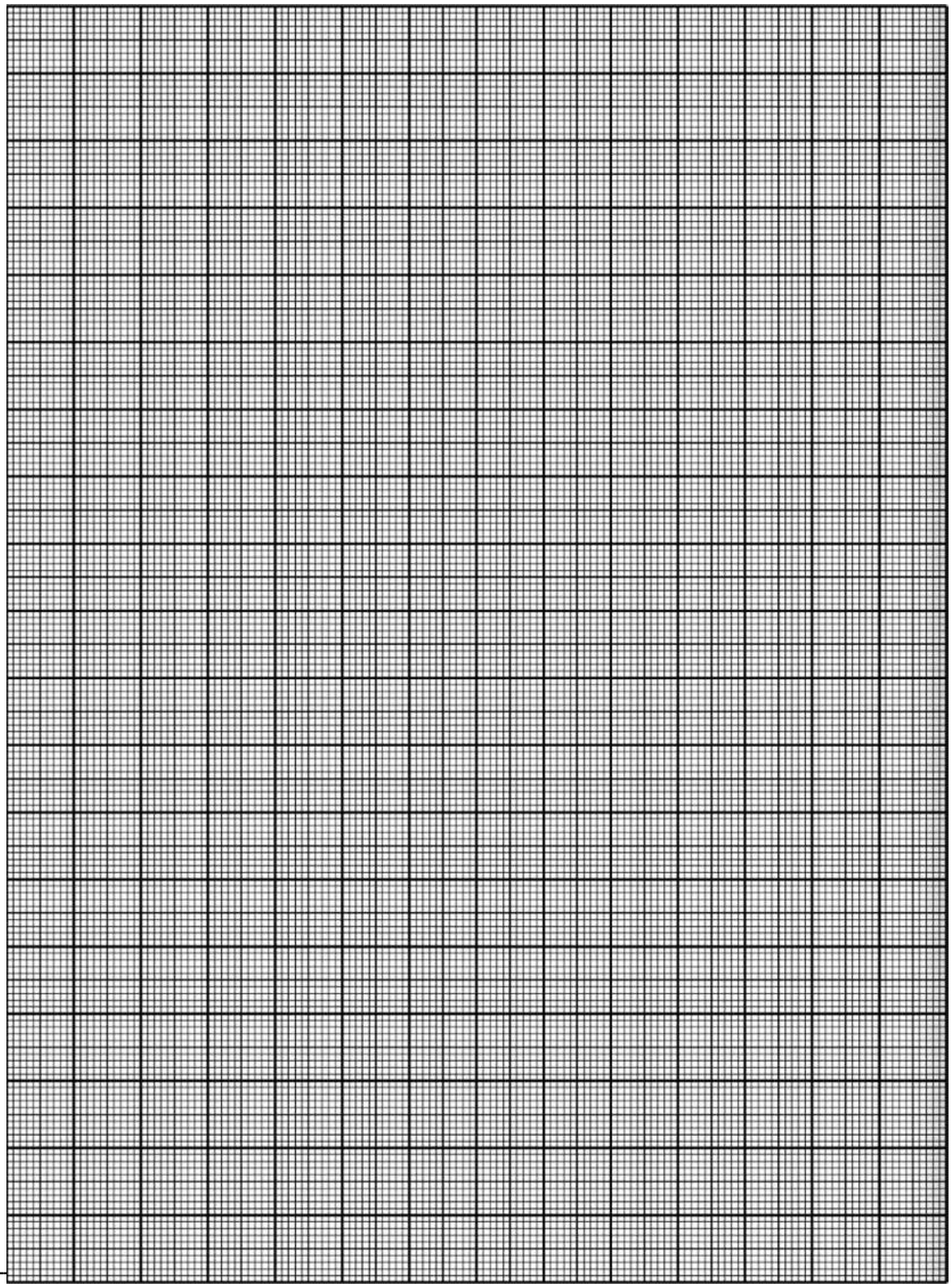
1. Choice of scales (0.1 marks total)
   a. Scale on both axis extends more than 2/3 of the paper = full 0.1 marks,
2. Correct axis and labels (0.4 marks for each complete correct axis)
   a. X axis = length (cm) = 0.1 marks
   b. Y axis = Resistance (Ω) = 0.1 marks
   c. Check each point is +/- 0.1 Ω of the values listed in the table, award 0.05 for each correctly plotted point up to a maximum of 0.3 marks for this total

Drawing the line of best fit between the points

0.2 for a straight line drawn with a ruler

0..2 for line fits all the points closely without bias at either end of the line

Name…….. **Code** ……..



3. What does the slope and the y-axis intersection point represent? write “α” and “β” in the correct places in the table below (0.6 marks)

resistivity of the wire	
resistance of the multimeter	
resistance of the connectors	B or y interce pt
voltage of the multimeter’s battery	
wire’s resistance per unit length	a or slope
length of the wire	
the diameter of the wire	

0.3 for each correct answer

4. Extract from the graph the resistance per per unit length **λ** of the wire.

λ = …… range 0.075 to 0.200……**Ω/cm**
(0.3 marks)

Part 2 – measurement using a Wheatstone bridge

A Wheatstone bridge is a method to measure resistances, by connecting them according to figure 2.1. In this configuration it is possible to get a relation between the four resistances in the circuit by measuring the voltage between nodes B and C.

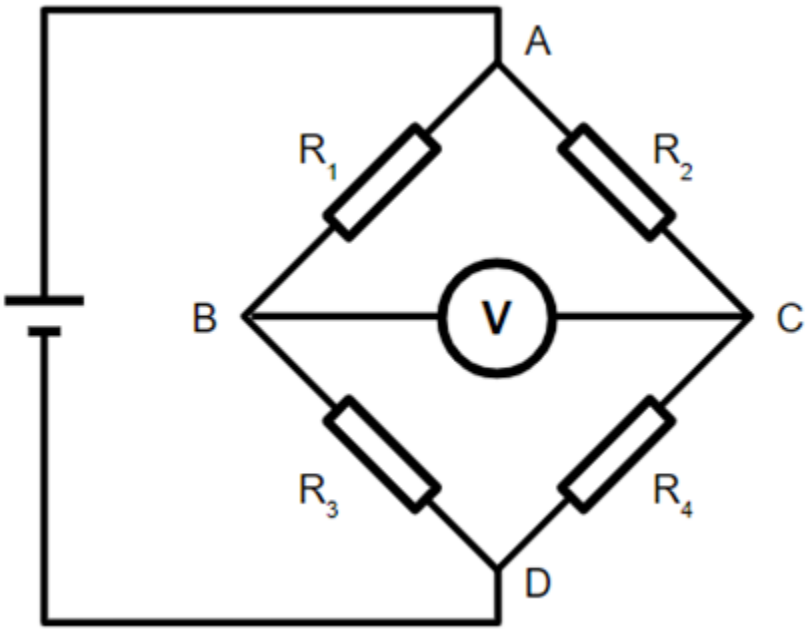


Fig. 2.1 – Wheatstone bridge

1. Show theoretically that whenever the resistances justify the relation:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

then the measured voltage should be zero. Be sure to use only diagrams and equations.

I1 :12 R1 + R3 = R2 + R4 0.1 marks

(R1 + R3) I1 = (R2 + R4)I2 I1R4 = I2R3 0.2 marks

V = R1(E/R1+R3) – R2(E/R2 + R4) = 0 I2R2 = I2R1 0.2 marks

Rearrange to get R1/R2 = R3/R4

(0.5 marks)

2. For this experiment we will use the two resistors marked as 5.0kΩ, and the resistor marked 5.8 MΩ. Use your multimeter to measure the resistances of these resistors and write down your results.

$R_{5.0k\Omega,1}$ = ……value +/- 5 %……

$R_{5.0k\Omega,2}$ =…… value +/- 5 %……

$R_{5.8M\Omega}$ =…… value +/- 5 %…… (0.1 mark)

3. Measure the Voltage of the battery directly using the multimeter and write down your result.

(0.1 mark)

U =……9.0V……

In this experiment we will use a bread-board to construct our circuit. The different holes of the bread-board are electrically connected to each other in groups of five, as shown by the blue

lines in figure 2.2. Thus, for instance, the resistors R_1 and R_2 in the figure are connected in parallel, while R_3 and R_4 are connected in series.

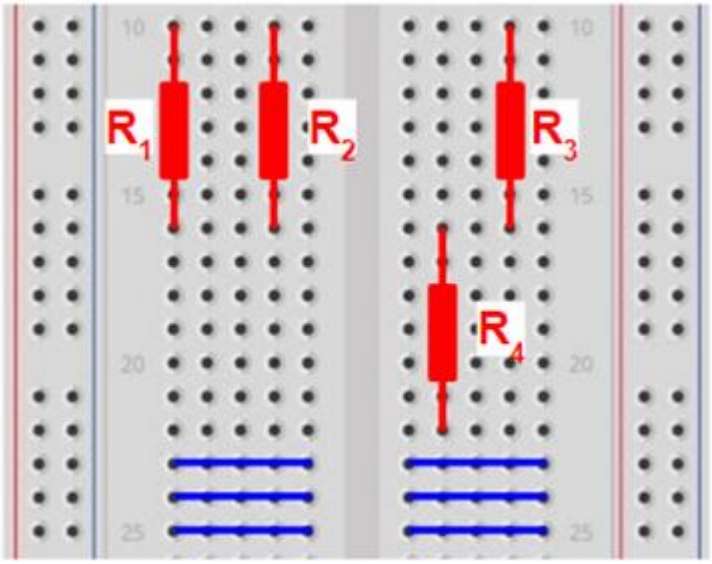
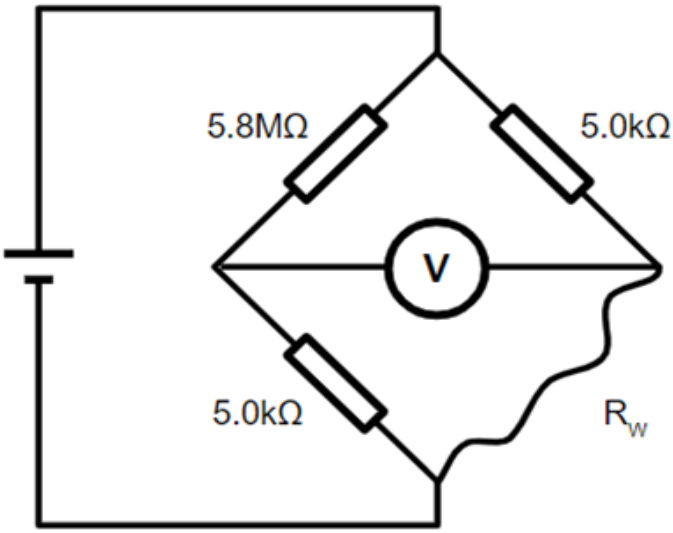


Fig. 2.2 – An example of a bread board

4. Connect the circuit according to the diagram below. Use a L=80cm length of wire as R_w. Use the provided bread-board to connect the different components in the correct manner, and use the crocodile wires to connect to the battery. **CAUTION** – do **NOT** connect the battery in any other way other than the one depicted in the diagram! Incorrectly connecting the battery could cause it to short and **RUIN** your equipment! Avoid **ANY** contact between wires that belong to different parts of the circuit!



5. Record the voltage reading in the table below. Repeat the measurement for the different values of L and record your measurements in the table:

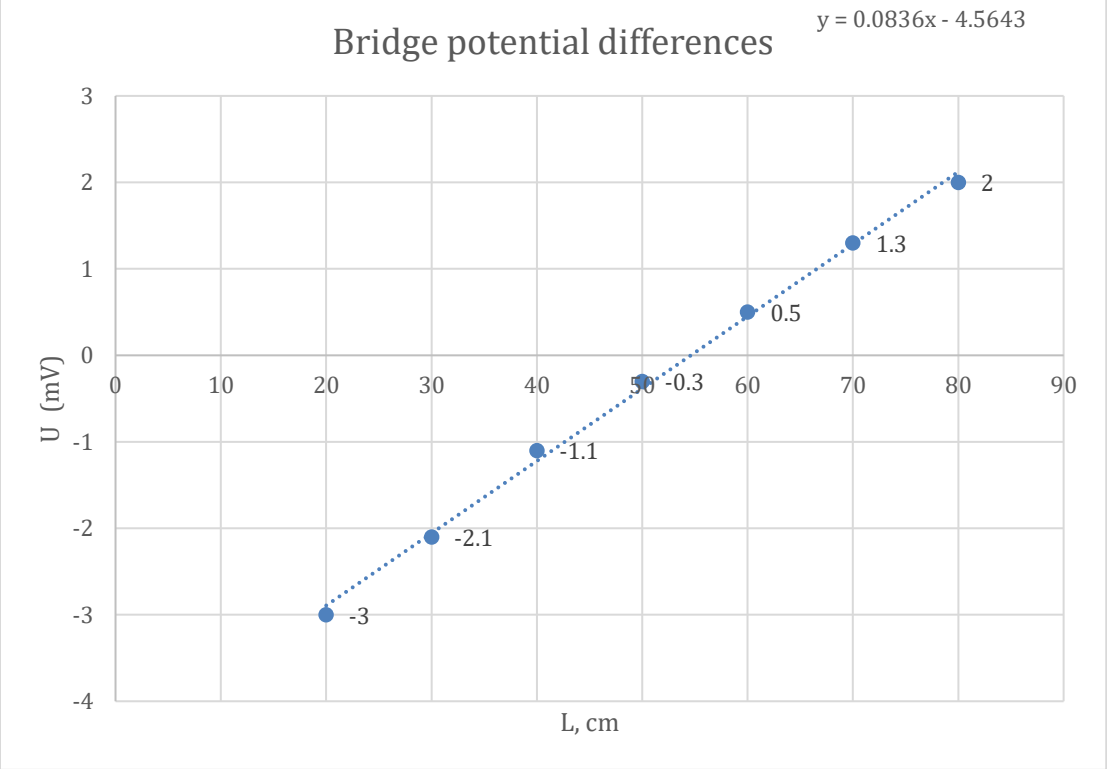
Table 2.2

L[..]	$V_{measured}$[..]
20	- 3.0
30	-2.1
40	-1.1
50	-0.3

60	0.5
70	1.3
80	2.0

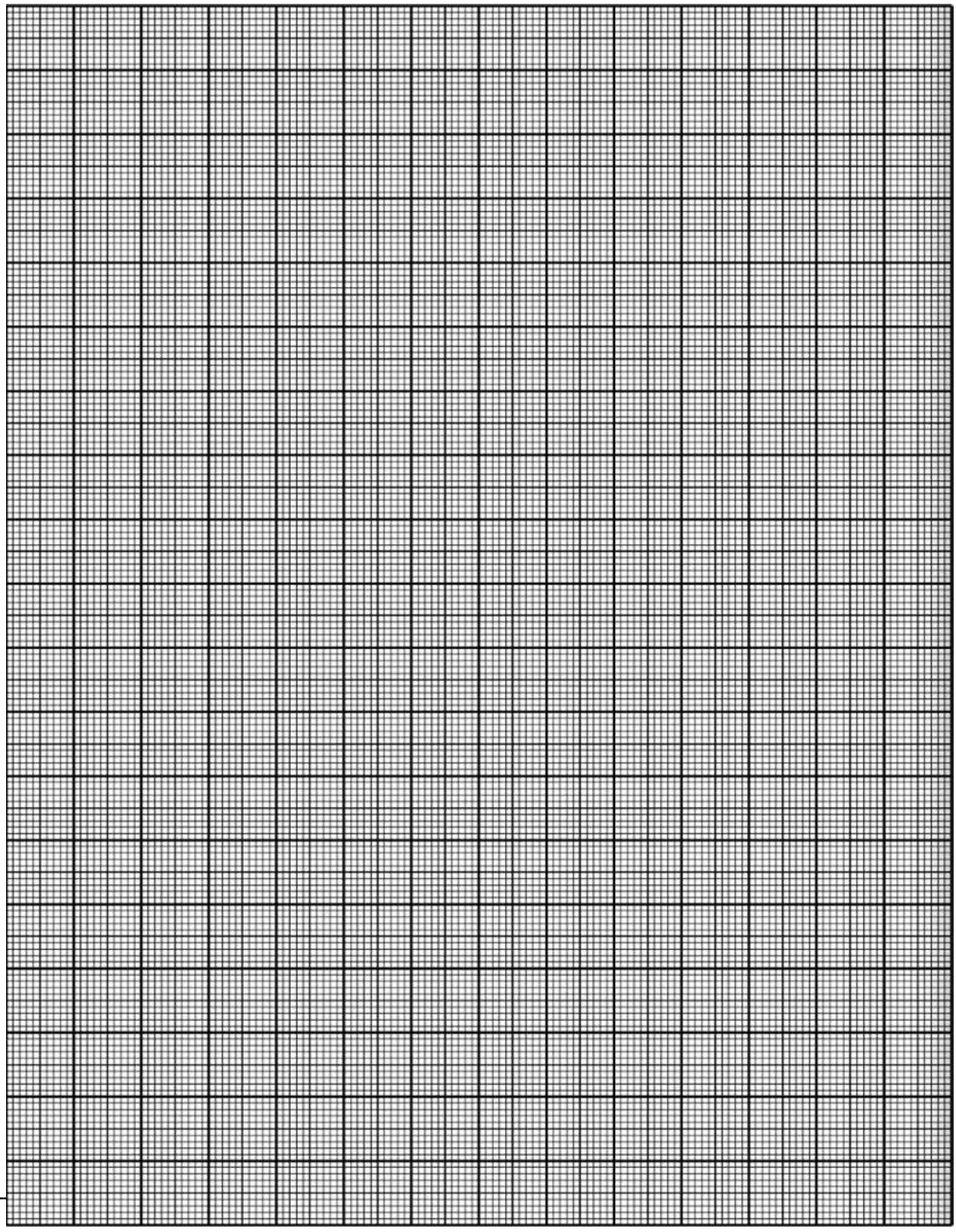
(0.6 marks)

6. Construct a graph of the measured voltage ($U_{measured}$) as a function of the length of the wire.



(1 mark)

Name…….. **Code** ……..



7. Which property of the graph can you use to extract the resistance per unit length of the wire? Mark an "X" below the correct answer: (0.2 mark)

slope of the graph	crossing of the x axis	crossing of the y axis
	X	

8. Use your graph to extract the resistance per unit length **λ** of the wire. make sure to use only equations and diagrams. (0.5 marks)

Length corresponding to x axis intercept = L

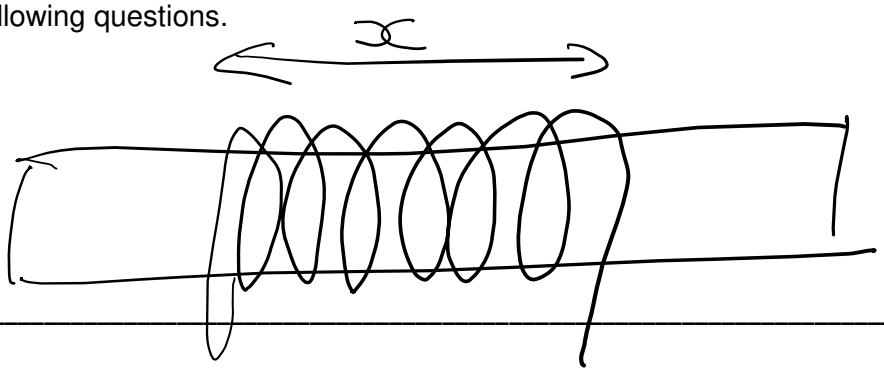
Resistance Rw = R1 x R4/R2 = 5.0x5.0/5.8 = 4.3

Λ = Rw/L = 4.3/ 55 = 0.078 Ohms/cm

λ = ……**Ω/cm**

Part 3 – acquiring the resistivity of the wire

1. Design a way to measure the diameter D of the wire as accurately as you can. Show your method by sketch and write down your result with the appropriate number of significant digits. If you are unable to complete this task, you may use D = 0.3 mm in the following questions.



Length = 0.1 marks

multiple turns = n

Number of turns = 0.2 provided more than 5

D = x/ n 0.3 marks

D = …… (0.6 marks)

2. Write down an equation to relate the resistance per unit length **λ**, the diameter D and the resistivity ρ of the wire.

$$\lambda = \frac{4\rho}{\pi D^2} \quad \text{or} \quad \rho = \frac{\pi D^2 \lambda}{4}$$

final equation: …… (0.3 mark)

3. Calculate the resistivity of the wire using the previous results you've obtained.

Use formula above to calculate using the teams value of Lambda and D OR using the value of D = 0.30mm award 0.3 marks for the correct calculation

Units of answer should be Ω cm or Ω mm or Ω m award 0.1 marks for the unit

ρ = …… (0.4 marks)

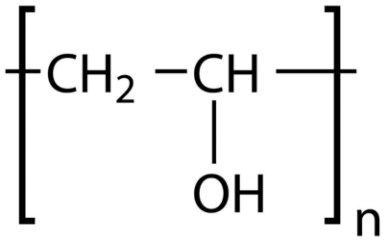
CHEMISTRY EXPERIMENT 3 (13 marks)

Part 1: Determining the average relative molar mass of polymer

Viscosity is a property of a liquid that can be defined as the resistance to flow. The viscosity of fluids such as blood or cerebrospinal fluid has a significant influence on their flow rate and the pressure of these fluids in the human body and so has a major physiological impact.

The purpose of this experiment is to model the hydrodynamic properties of body fluids using a polymer solution by investigating how the concentration of polymer molecules in an aqueous solution of polyvinyl alcohol (PVA) affects its viscosity.

Polymers are very large molecules composed of many identical subunits (monomers) bonded in a regular manner. The structure of the PVA molecule can be represented as:



The structure in this diagram represents one repeating unit of the polymer; the n represents the number of repeating units in a single polymer molecule. Polyvinyl alcohol does not ionise in water.

This model assumes that the polymer solutions are behaving in a Newtonian manner which means that when the liquids flow through a capillary, they obey Poiseuille's law:

$$volume\ flow\ rate = \frac{\Delta P \pi R^4}{8\eta L}$$

where η is the viscosity in mPa.s, R is the radius of the capillary, ΔP pressure difference between two ends of the capillary and L the length of the capillary.

When comparing two liquids flowing through the same narrow capillary, the ratio of the viscosity of two liquids (relative viscosity of liquid 1 to liquid 2) can be simplified to:

$$\eta = \frac{time\ of\ flow\ of\ liquid\ 1}{time\ of\ flow\ of\ liquid\ 2}$$

In this experiment you will use a viscometer to measure the time of flow for water and for various concentrations of PVA solution. You will calculate the viscosity of the PVA solutions relative to the viscosity of water and thereby determine the relationship between the relative viscosity and the polymer concentration. Finally, you will use this information to estimate the average relative molecular mass of the polymer.

Procedure 1. Preparing diluted solutions of PVA

List of equipment (some of the equipment might be shared with other experiments):

Cups
Viscometer stand (bigger cup with a small notch at the bottom)
measuring cylinder
Plastic pipette
Tray
Viscometer (small plastic bottle with a capillary attached)
Ruler
Marker
Distilled water
PVA stock solution (2 g of PVA/100 mL water)
Sodium chloride stock solution (10 g / 100 mL water)
Stop watch
Waste container
Wooden spoon

1. Label six cups according to Table 1 below.

2. In the labelled cups, use your measuring cylinder and a plastic pipette to prepare five diluted PVA solutions from the 2.0g/100 mL stock solution provided. The solutions should each have a total volume of 100 mL and should be prepared with the concentrations shown in Table 1 below. Record the volumes used in Table 1 below.

Table 1: Composition of PVA solutions

Sample	**Volume of PVA stock solution (mL)**	**Volume of distilled water added (mL)**	**Concentration of mixture (g/100mL water)**
Water	0	100	0
1	10	90	0.20
2	20	80	0.40
3	30	70	0.60
4	40	60	0.80
5	50	50	1.0

All correct = 1 mark

0.2 for each correct line, ignore decimal places

(1.0 mark)

Procedure 2. Measuring the viscosity of each solution.

1. Perform this experiment on a tray.

2. Rinse the viscometer with about 1cm of water (measured from the bottom of the viscometer).

3. Make two marks on the viscometer bottle. The marks should be 5 cm (lower mark) and 7 cm (upper mark) above the base of the bottle.

4. Raise the viscometer by placing it on an inverted bigger cup with a small notch. Make sure that the capillary sits in the notch. Hold a finger over the capillary to stop the flow and pour the water into the viscometer. The level of the liquid should be above the upper mark.



5. Move the water cup under the capillary to collect the draining liquid. Remove your finger and allow the solution to freely flow through the capillary until the liquid level reaches upper mark, then start the stopwatch. Stop the timing when the liquid level reaches lower mark.

6. Repeat these measurements for the water to obtain three reproducible results. Record your measurements for the water in Table 2 below.

7. Rinse the viscometer with a small volume of the next solution you wish to test and allow it to drain through the tube. If the rinsing solution doesn't drain through the tube, place your thumb over the neck of the bottle and squeeze the bottle gently.

8. Repeat steps 4 to 7 with the remaining solutions.

9. Record all these measurements in Table 2 below.

Table 2: Flow time measurements

Sample	Time of flow (s)			Avg flow time (s)
	Measurement #1	**Measurement #2**	**Measurement #3**	
Water				40.0 – 50.0
1				42.0 – 57.0
2				55.0 – 70.0
3				62.0- 85.0
4				74.0 – 100.0
5				85.0 -115.0

1 mark for all results within the range as shown by the average time – reduce 0.2 for each average outside the range

2 mark for consistent results in each solution measurement e.g. Solution 1 range +/ - 1.0 either side of their average -

Solution	+/-	+/-	+/-	+/-
Water	1.0	1.5	2.5	> 2.50
1	1.0	1.5	2.5	> 2.50

2	1.0	1.5	2.5	>2.50
3	1.5	2.5	3.0	>3.00
4	1.5	2.5	3.0	>3.00
Marks	0.4 for each soln	0.3 for each soln	0.2 for each soln	0.1 for each soln

Consider water and solutions 1 to 4 only for the assessment of the precision only
(3.0 marks)

Analysis of results

Estimation of the relative viscosity of the PVA solutions

2. Calculate the relative viscosity of each solution:
   $\eta = \frac{t_s}{t_w}$ where t_s is the average flow time of each PVA solution and t_w is the average flow time of the water.

Table 3: Relative viscosity

Concentration of PVA (g/100 mL)	Average flow time (s)	Relative viscosity η
0	40-50	1.00
0.20	40 – 50	1.05- 1.20
0.40	45 – 55	1.21 -1.45
0.60	55 – 70	1.46 -1.75
0.80	75 – 95	1.76 – 2.00

1.0	80 -110	1.95 -2.50

0.2 for each correct line excluding the water

(1.0 marks)

2. Calculate the reduced viscosity of each solution:

$$\eta_r = \frac{\eta - 1}{c}$$

Where c is concentration of PVA in g/ 100 mL water. Note that 1 dL is 100 mL.

Table 4. Reduced viscosity.

Concentration of PVA (g/100 mL water)	Reduced viscosity (dL/g)
0.20	
0.40	
0.60	
0.80	
1.0	

Use spreadsheet to check calculations are correct based on each team's own results, 0.2 marks for each correct calculation, expect 2 decimal places but will not mark decimal places

(1.0 mark)

3. Using the graph paper on the following page, plot a graph of the reduced viscosity versus concentration of PVA and establish a line of best fit. (2,5 marks)

Graph preparation (1.5 marks total)

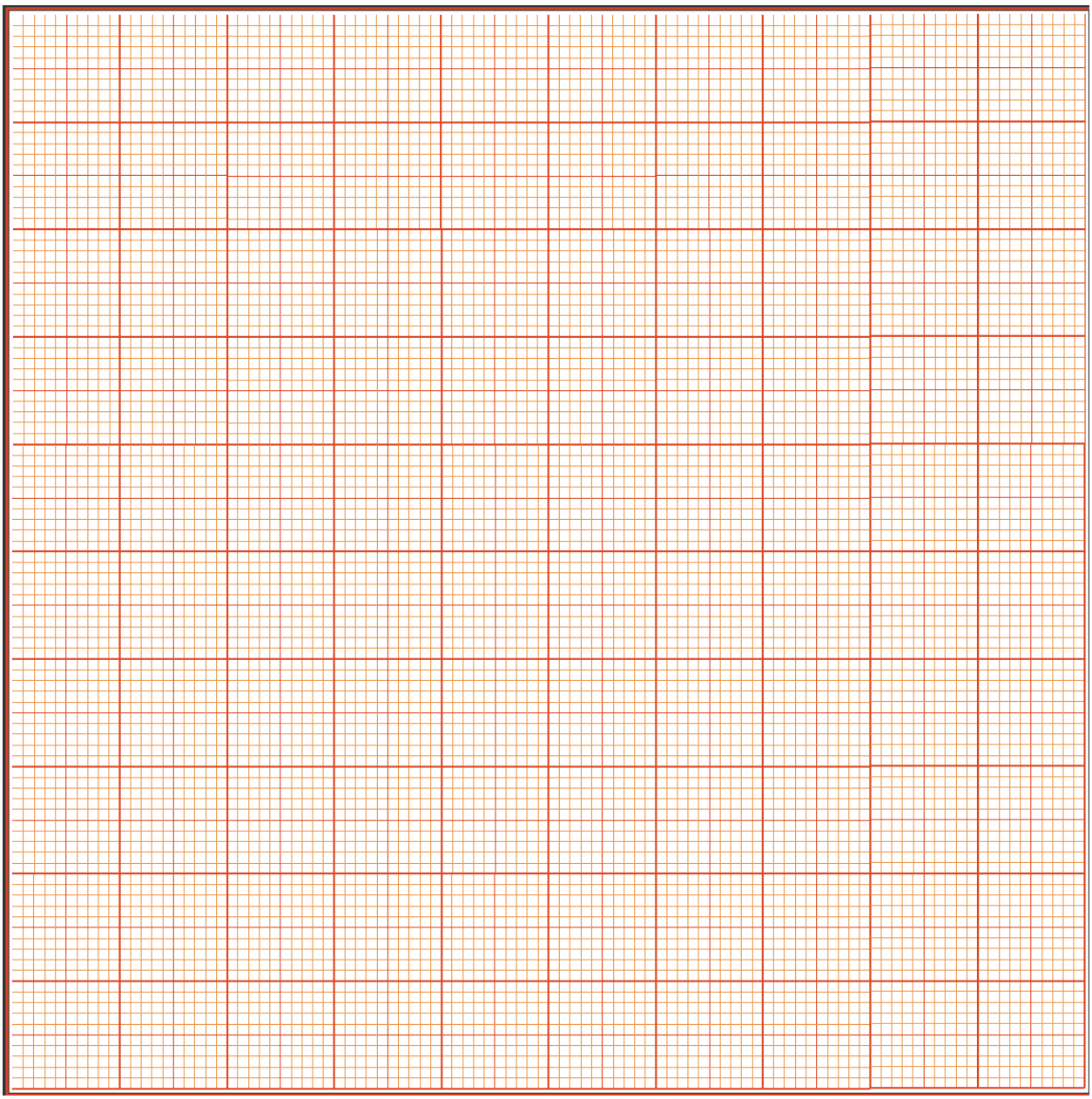
1. Choice of scales (0.2 marks total)
   a. Scale on both axis extends more than 2/3 of the paper = full 0.2 marks, if the scale on both axis extends between 2/3 and 1/3 of the paper = 0.1 marks
2. Correct axis and labels (0.4 marks for each complete correct axis)
   a. X axis = Concentration of PVA (Choice) = 0.2 marks Label (Concentration of PVA)= 0.1 marks, Units (g/100mL) = 0.1 marks
   b. Y axis = Reduced Viscosity (Choice) = 0.2 marks Label (Reduced viscosity)= 0.1 marks, Units (dL/g) = 0.1 marks
   c. Check each point is +/- 0.01 of the values listed in the table, award 0.1 for each correctly plotted point

Name…….. **Code** ……..

Drawing the line of best fit between the points

0.5 for a straight line drawn with a ruler

0.5 for line fits all the points closely without bias at either end of the line



4. The intrinsic viscosity of polymer is a measure of the contribution of the solute to the overall viscosity of the solution. Determine the intrinsic viscosity of PVA (in dL/g) by extrapolating your graph to c = 0.

Agrees with c = 0 from their graph +/- 0.05 = full 1 mark

+/- 0.075 = 0.5 marks

+/- 0.1 = 0.2 marks

Intrinsic viscosity of PVA η_i= _____dL/g (1.0 marks)

5. The intrinsic viscosity of a polymer ~~solution~~ can be used to determine the average relative molecular mass (M_r) of a polymer, using the Mark-Sakurada-Houwink equation:

$$\eta_i = KM_r{}^a$$

For this system, the constants are:
K = 5.43×10^{-4} dL/g
a = 0.64

Estimate the average molecular mass of the PVA molecules to 1 significant figure:
_____ (1.5 marks)

Correctly used formula based on their results = 1.5 marks (use spreadsheet)

1.0 marks if calculated omitting a or K

PART 2: Investigating the effect of small molecules on the viscosity of polymer solutions

Carry out a further experiment to test whether the presence of small molecules or ions such glucose, urea or sodium chloride will affect the relative viscosity of a polymer solution.

You are provided with a solution of sodium chloride with concentration 10 g/100mL. Use this to prepare 100mL of a solution containing 1.0 g PVA/100mL solution and 5.0 g NaCl/100mL solution.

Follow Procedure 2 above to measure the average flow time of this solution.

Compare this value with that of the original 1.0g/100mL polymer solution. Indicate how the two values compare below.

Name……. **Code** …….

1. Record your data here:

Table 6. *Flow time measurements of PVA/NaCl solution*

Sample	**Time of flow (s)**			**Avg flow time (s)**
	Measurement #1	**Measurement #2**	**Measurement #3**	
PVA / NaCl				85 – 115

The marks are divided into two parts: 0.5 marks for the avg flow time in the range specified and 0.5 marks for the measurements being consistent.

If the avg result in this range and the measurements are within 5 secs of each other award full mark

If the measurements vary by more than 5 seconds from the avg award 0.5 marks

If the avg flow time is not between 75 and 110 secs but is between 65 and 120 secs award 0.2 marks

(1.0 mark)

2. According to your results, which of the following explanations is the best fit for your results (indicate with X)?

The addition of sodium chloride to the PVA solution significantly <u>increases</u> the viscosity of the solution due to a reaction between sodium chloride and the hydroxyl (-OH) groups on the PVA molecules which causes the PVA molecules to break down into smaller fragments.	
The addition of sodium chloride to the PVA solution significantly <u>decreases</u> the viscosity of the solution by increasing the kinetic energy of the molecules.	
The addition of sodium chloride to the PVA solution significantly <u>increases</u> the viscosity of the solution by decreasing the kinetic energy of the molecules.	

The addition of sodium chloride to the PVA solution does not significantly affect the viscosity of PVA solution because the polymer is not ionic.	X
The addition of sodium chloride to the PVA solution significantly increases the viscosity of the solution due to exothermic dissolution of sodium chloride.	

Compare the avg flow time for this experiment to the avg flow time for the 1.0 g/ 100 mL result the Team obtained in the first part. The result should be almost the same.

If the avg flow time for this experiment is significantly longer that the avg flow time for the 1.0 g/100ml result in the Team's first part then the answer here should be the fith (last) box – award the full mark

If the avg flow time for this experiment is significantly shorter that the avg flow time for the 1.0 g/100ml result in the Team's first part then the answer here should be the third box – award the full mark

(1.0 mark)

Experimental Task 4 : Investigating pH using Anthocyanins

Introduction:

Anthocyanins and flavonoids are compounds highly concentrated in the petals of many garden flowers. They are currently used in the food industry as an alternative to synthetic colorants because of health benefits as antioxidants and its changes in color by the pH.

Suppose that you are a young scientist who is interested to know the pH of a popular drink in Colombia: Spamonethaca®. To make that, you will build a matrix of colors using extracts from common flowers in the garden. Please follow the next instructions to do your analysis.

Materials:

- Flowers from 3 species (*Hibiscus sinensis, Bougainvillea sp., Zantedeschia aethiopica*)

- Marker (fineliner)
- 7 glass assay tubes
- 1 rack for tubes
- 1 glass stirrer
- 3 Plastic Pasteur pipettes (Instruction to re-use: rinse it three times with a small volume of distilled water.)
- 2 pH test strips (no more than 2 will be provided!)
- pH color chart
- Biology Colorimetric Analysis chart (separate paper)
- Plastic film (Saran wrap)
- NaOH 0.5M
- HNO_3 0.2M
- pH 5 solution
- pH 7 solution
- Ethanol 80%
- Distilled water
- Spamonethaca® solution
- Wash bottle (water)
- Big waste container
- Paper towels
- Gloves
- 10 mL Measuring Cylinder

BE CAREFUL WHEN WORKING WITH HNO_3 and NaOH!! DO NOT GET IT ONTO YOURSELF Please wear gloves when handling these reagents

Procedure and questions:

1. Make extracts from the petals

a) Label 3 glass test tubes.

b) Take a similar amount of petals for each of the 3 species and put them in the respective tubes. Make sure you use enough petals to fill approximately 2 cm of tube.

c) Use a glass stirrer to crush the petals. Clean the stirrer after each use.

d) Add 2 mL of ethanol to each tube and mix well with the crushed petals.

e) Use some plastic foil to cover the top of each tube.

f) Leave this for **30 minutes** to complete the extraction of the anthocyanins.

2. Making the pH solutions

a) Solution pH 5 and pH 7 are provided.

b) Label 2 glass tubes with pH 5 and pH 7.

c) Use a plastic Pasteur pipette to add 5 mL of each pH solution to the respective glass tubes. Use a clean pipette each time.

d) Label 2 glass tubes with “pH A” and “pH B”.

e) Use plastic pipettes and a graduated cylinder to make the two pH solutions according to the table below:

LABEL: pH A		**LABEL: pH B**	
Step 1	***Step 2***	***Step 1***	***Step 2***
2.5 mL water	2.5 mL HNO_3 0.2 M	4 mL water	2.5 mL NaOH 0.5 M

f) Use the pH test strips provided to determine the pH of “pH A” and “pH B”. For this, use a plastic pipette to pipette some of the solution on each of the squares of the test strips.

g) [1.00 marks] Read your values using the chart provided and record them below.

pH A	pH B
1 to 3	9 - 14

3. Colorimetric analysis

a) Use the separate paper provided “Biology Colorimetric Analysis” and cover it with plastic film. Make sure the entire paper is covered and all air bubbles are removed. Smoothen out the film completely to create a smooth surface.

b) Use a plastic Pasteur pipette to add 1 drop of solution “pH A” to the “pH A” column on the smooth film surface.

c) Repeat for solutions pH 5, pH 7 and “pH B” in their respective columns. Make sure to use a clean plastic pipette for each pH solution.

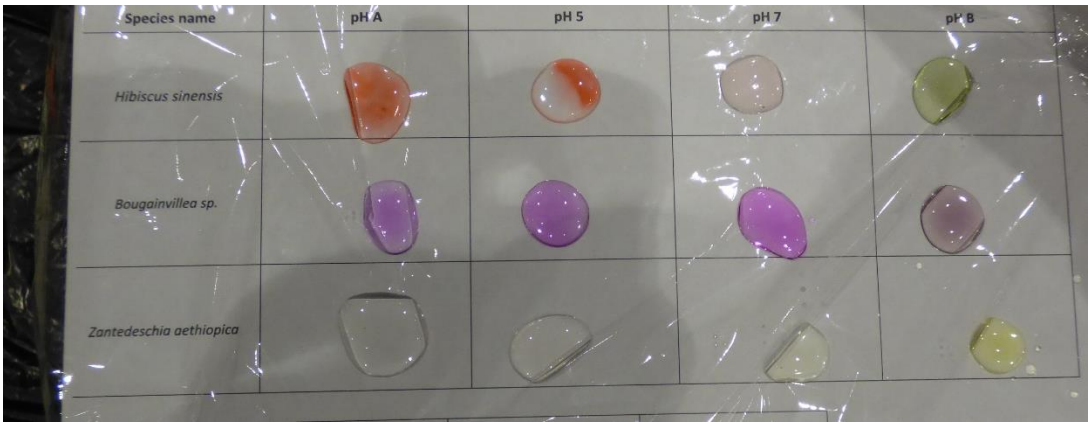
d) Add 1 drop of the anthocyanin extract of *Hibiscus sinensis* to each of the pH solutions on the Hibiscus row on the smooth film surface.

e) Repeat for *Bougainvillea sp.* and *Zantedeschia aethiopica*. Use a clean plastic pipette each time.

f) Leave this for 1 minute and ask the practical assistant to take a **photograph**.

g) [1.20 marks]

Mark Scheme for Photos of plant anthocyanin extracts



Total available 1.2 marks.
Correct order of colours vertically red top, purple middle yellow to colourless bottom = 0.2
Top line shows evident graduation from red to green with major change after pH5 and pH7 = 0.4
Middle line shows evident change between pH 7 and pH B = 0.4
Bottom line shows very little change with darker colour at the end = 0.2

	Signature of practical assistant
Photograph taken	See photo mark scheme

h) [0.50 marks] What is the best explanation for the change in color? Mark with an **X** the correct option.

	Mark with X
Irreversible reduction	
Protonation/deprotonation	X

Hydroxylation	
Nitrosylation	

4. Determining the pH of Spamonethaca®

a) [1.00 marks] Select the one species with the anthocyanin that has a clearly visible color change in both the acidic and the basic range.

	Write the name of the species below
Species selected	*Hibiscus*

b) Use a plastic Pasteur pipette to add 1 drop in each of the Spamonethaca® labeled area's (S1 and S2) on the "Biology Colorimetric Analysis" film sheet.

c) Add 1 drop of the selected anthocyanin extract to area S1.

d) Add 1 drop of water to area S2.

e) Leave this for 1 minute and ask the practical assistant to take a **photograph**.

f) [0.50 marks]

Second Picture



See ideal image above – total marks available = 1.0 mark
S1 should be red colour = 0.2
S1 should have a colour between pH A and pH 5 = 0.4 marks
S2 should be pale cream / yellow = 0.2
S2 should fit in the pH colour range between pH7 and pH B = 0.2

	Signature of practical assistant
Photograph taken	See photo mark scheme

g) [1.00 marks] Identify the role of S1 and S2. Mark with an **X** the correct term(s) that apply to each condition. If the term does not apply to the condition, mark with **O**.

Term	**S1**	**S2**
Contrast		
Test	X	
Placebo		
Negative control		X
Positive control		

h) [0.50 marks] Based on your results, give an estimation of the probable pH of Spamonethaca®. Mark with an **X** only the correct answer.

Estimation of the pH	**Mark with X**
Strongly acidic	X
Slightly acidic	
Neutral	
Strongly alkaline	

5. Biological implications

a) [0.50 marks] Which one of these molecules/molecular complexes is/are responsible for regulating anthocyanin color in living plant cells. Mark with **X** the correct answer(s).

Molecule/molecular complex	**Mark with X**
ATP synthase of chloroplasts	
ATP synthase of mitochondria	
ATP synthase of vacuole	
Proton pump of plasma membrane	X

Proton pump of vacuolar membrane	

b) [0.80 marks] What possible health effect(s) could be associated with excessive consumption (2L per day) of Spamonethaca®? Mark with X the correct answer(s).

Health effect	**Mark with X**
Worsening of peptic ulcer	X
Erosion of enamel	X
Interference with protein digestion	
Increased susceptibility to flu	

0.4 for each correct answer

Experiment 5 Determining the species of Coffee -Recognize Coffea Arabica

Recognize Coffea Arabica

Coffea arabica is originally endemic from the southwestern of Ethiopia, was the first cultivar species of coffee known used to the production of beverage. Currently this plant represents 60% of the world's production. In Colombia, part of the economy depends on it and it is well known for its high quality taste characterized by soft and exquisite aroma, which give the Colombian coffee international recognition.

During this task you will provide a precise description of this plant, then you will use a typical dichotomous key to check its family.

Look carefully at the provided part of the coffee plant, then identify the correct term to describe the next characteristics.

Name…….. **Code** ……..



You can use this picture of *Coffea Arabica* plant for solving any question.

Name…….. **Code** ……..

1. [1.00 marks] Draw a simple image of the provided plant. The image should be composed of at least two leaves and you must draw the veins structure, and detailed margins of the leaves as well as composition of leaves.

LEAF DETERMINATION

1. [0.25 marks] Mark with X the right leaf shape of observed plant. If none of them is correct leave blank.

X	Eliptical
	Linear
	Rhomboid
	Cordate

2. [0.25 marks] Mark with X the right type of leaf of observed plant. If none of them is correct leave blank.

X	Simple
	Compound

3. [0.25 marks] Mark with X the right type of compound leaves of observed plant. If none of them is correct leave blank.

	Even pinnately compound
	Odd pinnately compound
	Palmately compound

4. [0.25 marks] Mark with X the right type of leaf arrangement (phyllotaxy) of observed plant. If none of them is correct leave blank.

	Alternate
X	Opposite
	Whorled

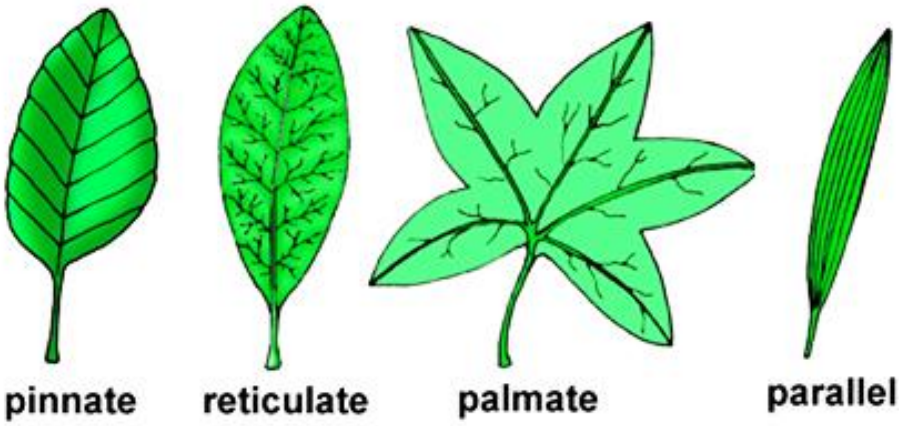
5. [0.25 marks] Mark with X the right type of leaf surface of observed plant. If none of them is correct leave blank.

	Rugose – Wrinkled, typical leaves of the mint family
X	Glabrous – Without hairs of any kind
	Pubescent – With a hairy surface
	Scurfy – Covered with small scalelike particles
	Viscid (Viscous) – Covered with sticky or resinous secretion

6. [0.25 marks] Mark with X the right type of main venation of observed plant. If none of them is correct leave blank.

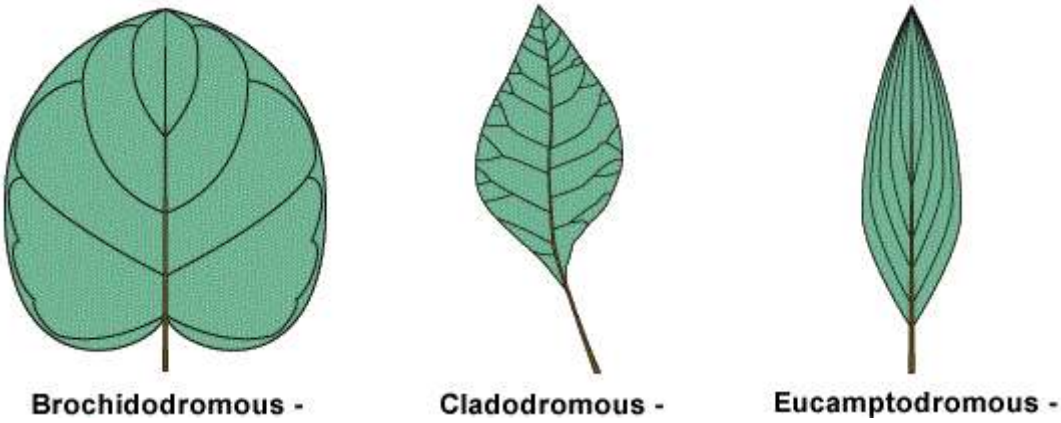
X	Pinnate
	Reticulate
	Palmate
	Paralell

Name…….. **Code** ……..



7. [0.25 marks] Mark with X the right type of secondary venation of observed plant. If none of them is correct leave blank.

	Brochidodromous
X	Cladodromous
	Eucamptodromous



FLOWER DETERMINATION

8. [0.25 marks for all correct] Mark with X all the right types of observed flower. If none of them is correct leave blank.

X	Complete
	Incomplete
	Monoecious
X	Dioecious

9. [0.25 marks] Mark with X the right type of flower symmetry of the observed flower. If none of them is correct leave blank.

X	Actinomorphic (multiple lines of radial symmetry)
	Zygomorphic (single line of radial symmetry)

10. [0.25 marks] Write how many of these parts the observed flower has: Use also the provided pictures.

Calix	5
Corolla	5
Stamens	5
Styles	1
Stigmas	2
Carpels	2



11. [0.25 marks] Mark with X the type of flowers ovaries. If none of them is correct leave blank.

X	Epigynous – flower having the ovary enclosed in the receptacle, with the stamens and other floral parts situated above
	Hypogynous – flower having the stamens and other floral parts situated below the carpels (or gynoecium)
	Perigynous – flower having the stamens and other floral parts at the same level as the carpels

Note: Our own image

FRUIT DETERMINATION

12. [0.25 marks] Circle the correct type of fruit on the image A. Use the picture of coffee fruit marked Figure B in the next question. If none of them is correct leave blank.

Name…….. **Code** ……..

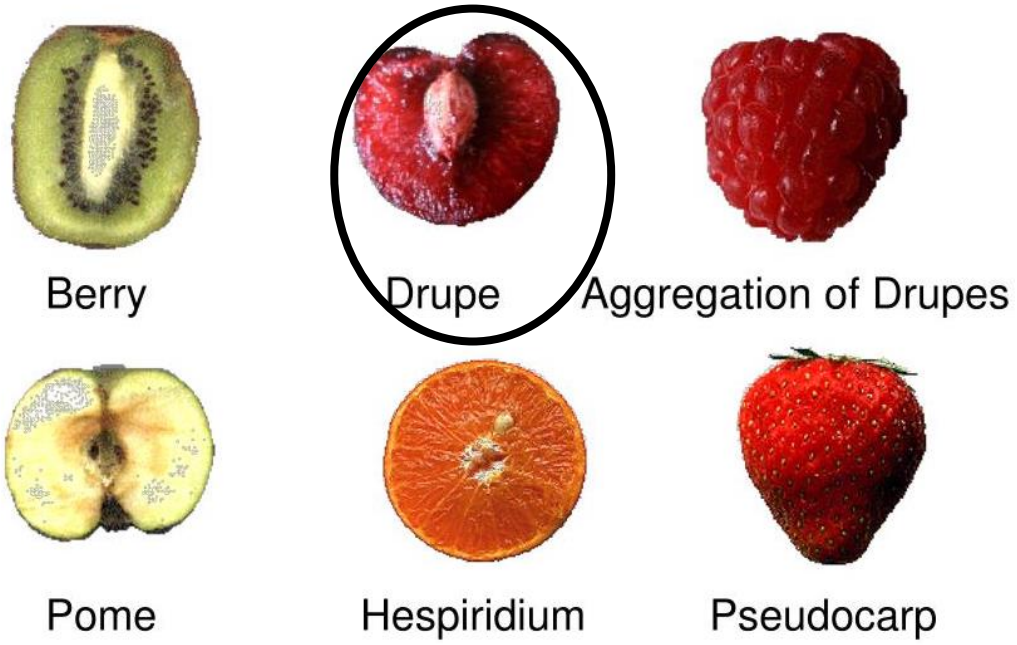


Figure A

13. Identificate parts of the fruit by writing corresponding letters in the blank boxes of Figure B.

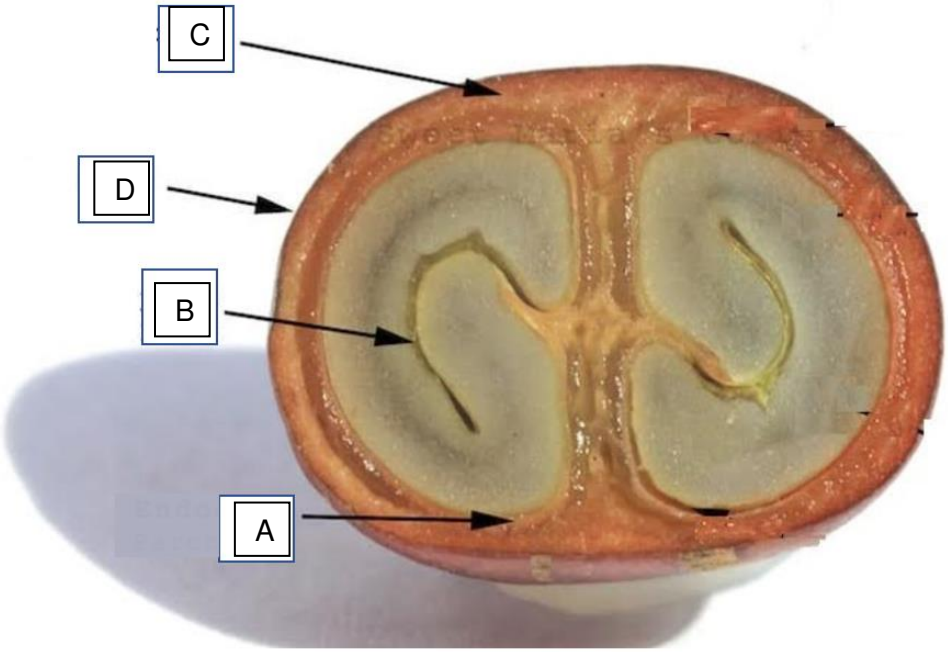
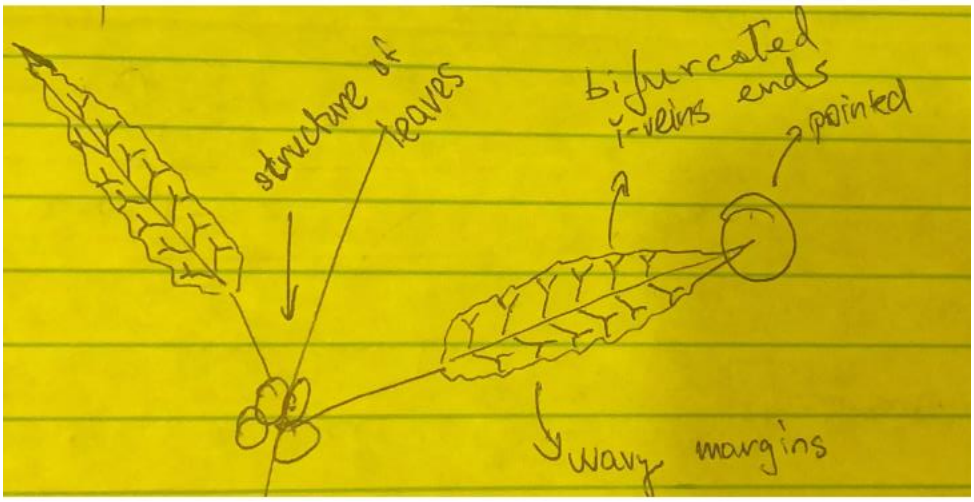


Figure B

A – endocarp
B – endosperm fold
C – mesocarp
D – exocarp

FAMILY IDENTIFICATION

14. [1.00 marks] Draw simple image of the provided plant. The image should be composed of at least two leaves and you must point the veins structure, and detailed margins of the leaves as well as composition of leaves.



[0.25 for each from leaves structure, wavy margins, pointed ends and bifurcated vein ends; students don't have to point details with words, its just for marking]

15. [1.50 marks for right answer (1.00 marks if the answer using find out characteristics by the particular student is right)] Use the dichotomic key to determine the family of provided plant. Use characteristics determined by you in the previous questions. **Rubiaceae**

1a. Plants 5–30 mm tall, parasitic on Picea, Larix, and Pinus **Viscaceae**
1b. Plants much taller or longer at maturity, not parasitic 2

2a. Leaves compound 3
2b. Leaves simple 10

3a. Gynoecium with 3 styles **Staphyleaceae**

3b. Gynoecium with 1 style 4

4a. Perianth zygomorphic **5**
4b. Perianth actinomorphic or absent **6**

5a. Plants trees with palmately compound leaves **Sapindaceae**
5b. Plants lianas with pinnately compound leaves **Bignoneaceae**

6a. Plants lianas (though woody only near base); flowers with numerous stamens; fruit an achene terminated by an elongate, plumose style **Ranunculaceae**
6b. Plants upright shrubs or trees; flowers with 2–12 stamens; fruit otherwise **7**

7a. Leaflets punctate with aromatic glands **Rutaceae**
7b. Leaflets not punctate 8

8a. Fruit a samaroid schizocarp;androecium composed of 4–12 stamens, commonly 8 **Sapindaceae**
8b. Fruit samara or drupe; androecium composed of 2 or 5 stamens **9**

9a. Perianth absent; androecium composed of 2 stamens; fruit a samara; flowers usually unisexual; trees at maturity **Oleaceae**
9b. Perianth present and gamopetalous; androecium composed of 5 stamens; fruit a drupe; flowers bisexual; shrubs at maturity **Adoxaceae**

10a. Apical portions of the stem succulent; leaves minute and scale-like, 1–3 mm long; stems appearing jointed **Amaranthaceae**
10b. Apical portions of the stem is not succulent; leaves with foliaceous blades, mostly longer; stems not appearing jointed **11**

11a. Inflorescence flower heads, or capitula **Asteraceae**
11b. Inflorescence is not flower heads, or capitula **12**

12a. Perianth zygomorphic **Bignoneaceae**
12b. Perianth actinomorphic 13

13a. Inflorescence a cyme; flowers each with 8 or 10 stamens; petals pink-purple, 10–15 mm long **Lythraceae**
13b. Inflorescence a dense, spherical cluster as a short cyme; flowers each with 4-5 stamens; petals white, 5–8 mm long **Rubiaceae**