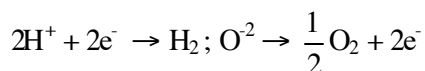
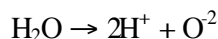


I. Determination of e/k_B Through Electrolysis Process

Background Theory

The electrolysis of water is described by the reaction :



The reaction takes place when an electric current is supplied through a pair of electrodes immersed in the water. Assume that both gases produced in the reaction are ideal.

One of the gases produced by the reaction is kept in a test tube marked by arbitrary scale. By knowing the total charge transferred and the volume of the gas in the test tube the quantity e/k_B can be determined, where e is the charge of electron and k_B is the Boltzmann constant.

For the purpose mentioned above, this experiment is divided into two parts.

Part A: Calibration of the arbitrary scale on the test tube by using a dynamic method.

This result will be used for part B

Part B: Determination of the physical quantity e/k_B by means of water electrolysis

You are not obliged to carry out the two experiments (part A and part B) in alphabetical order

The following physical quantities are assumed:

- Acceleration of gravity, $g = (9.78 \pm 0.01) \text{ ms}^{-2}$
- Ratio of internal vs external diameters of the test tube, $\alpha = 0.82 \pm 0.01$

The local values of temperature T and pressure P will be provided by the organizer.

List of tools and apparatus given for experiment (part A & B):

- Insulated copper wires of three different diameters:
 1. Brown of larger diameter
 2. Brown of smaller diameter
 3. Blue
- A regulated voltage source (0-60 V, max.1A)
- A plastic container and a bottle of water.
- A block of brass with plastic clamp to keep the electrode in place without damaging the insulation of the wire.
- A digital stopwatch.
- A multimeter (beware of its proper procedure).
- A wooden test tube holder designed to hold the tube vertically.
- A multipurpose pipette

- A vertical stand.
- A bottle of white correction fluid for marking.
- A cutter
- A pair of scissors
- A roll of cellotape
- A steel ball
- A piece of stainless steel plate to be used as electrode.
- A test tube with scales.
- Graph papers.

Note that all scales marked on the graph papers and the apparatus for the experiments (e.g. the test tube) are of the same scale unit, but *not calibrated* in millimeter.

EXPERIMENT

Part A: Calibration of the arbitrary scale on the test tube

- Determine a dynamic method capable of translating the arbitrary length scale to a known scale available.
- Write down an expression that relates the measurable quantities from your experiment in terms of the scale printed on the test tube, and sketch the experiment set up.
- Collect and analyze the data from your experiment for the determination and calibration of the unknown length scale.

Part B: Determination of physical quantity e/k_B

- Set up the electrolysis experiment with a proper arrangement of the test tube in order to trap one of the gases produced during the reaction.
- Derive an equation relating the quantities: time t , current I , and water level difference Δh , measured in the experiment.
- Collect and analyze the data from your experiment. For simplicity, you may assume that the gas pressure inside the tube remains constant throughout the experiment.
- Determine the value of e/k_B .

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ANSWER FORM

PART A

1. State the method of your choice and sketch the experimental set up of the method: **[0.5 pts]**
2. Write down the expression relating the measurable quantities in your chosen method: **[0.5 pts]**. State all the approximations used in obtaining this expression **[1.0 pts]**.
3. Collect and organize the data in the following orders : physical quantities, values, units **[1.0 pts]**
4. Indicate the quality of the calibration by showing the plot relating two independently measured quantities and mark the range of validity. **[0.5 pts]**
5. Determine the smallest unit of the arbitrary scale in term of mm and its estimated error induced in the measurements. **[1.5 pts]**

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PART B

1. Sketch of the experimental set up. [**1.0 pts**]

2. Derive the following expression:

$$I \Delta t = \frac{e}{k_B} \frac{2P(\pi r^2)}{T} \Delta h \quad [\mathbf{1.5 pts}]$$

3. Collect and organize the data in the following format : physical quantities (value, units) [**1.0 pts**]

4. Determine the value of $e k_B$ and its estimated error [**1.5 pts**]