VELOCITY OF ION MIGRATION

Experimental setup

Regulated power supply, flat chamber for ionic migration, digital multimeter, digital stopwatch, solution of potassium permanganate ($KMnO_4$) and potassium nitrate (KNO_3).

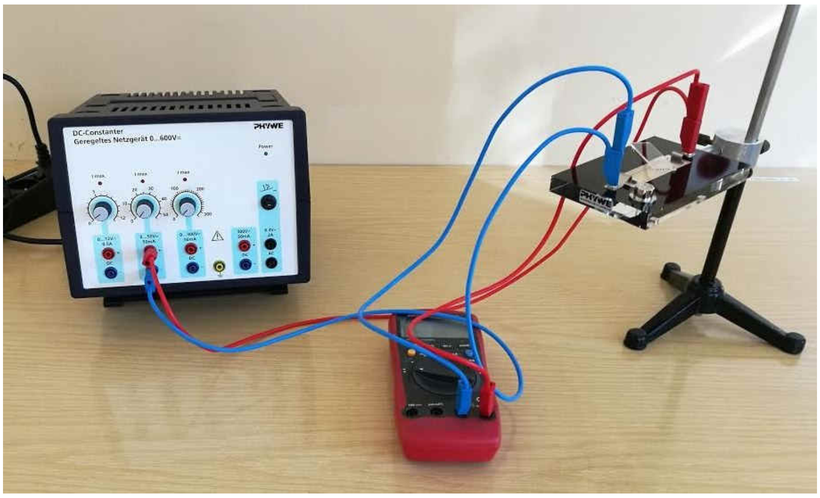

Fig. 1 View of the experimental setup

Course of measurements

A. Experimental part

1. Set the chamber for ion migration in the horizontal position precisely using the mounted water-level.
2. Connect the power supply to the chamber – positive pole (**red connecting cord**) to the anode and negative pole (**blue connecting cord**) to the cathode. Then connect the chamber to the digital multimeter using another pair of connecting cords – anode to the positive sign input (**red connecting cord**) and cathode to the negative sign input (**blue connecting cord**).
3. Do the measurements applying the solution of $KMnO_4$ at the concentration of 0,015 [M] and the solution of KNO_3 at the concentration of 0,0025 [M]
   A) Set the voltage of 20 [V] on the regulated power supply and then **turn it off.** In order to do the measurements one should cover the groove between the anode and the cathode applying a small cover plate. Then fill the hole at the anode with the KNO_3 solution using a single-use pipette. **Note, that the power supply must be turned off at this moment.** Because of the capillary effects, filling of the groove towards the cathode will be started (it is recommended to gently move the cover plate in the direction cathode-anode in order to accelerate the filling and provide a homogenous distribution of the KNO_3 solution in the groove). Filling of the hole at the anode should be stopped while KNO_3 solution will be reaching the edge of the hole at the cathode.

CAUTION: The KNO_3 solution should NOT be present in the hole at the cathode before the start of measurements!

Using another pipette fill the hole at the cathode with the $KMnO_4$ solution until it is reaching the groove between the cathode and the anode (there must be a direct contact between the solutions, if it is not the case, add the KNO_3 solution until the contact is obtained).

B) Turn the power supply on and check the voltage, **which should be equal to (20,0 $\pm$ 0,1) V**, using the digital voltmeter. This value will be needed for calculations. Permanganate ions will start to migrate in the groove towards the anode making a violet "column". While the migrating "column" is reaching the first scale mark on the chamber for ion migration, **turn the stopwatch on.** Then write down the time while the "column" is reaching next scale marks on the chamber. Write down the results to the table no 1 in the report sheet. After having written all results, turn the power supply off and then clean the migration chamber.

B. Presentation of results

1. Taking into account data from the table no 1, make the plot of $l = f(t)$ on a sheet of ploting paper. Then, on the basis of the plot, calculate the average ion migration velocity. Write down the result to the frame below the table 1.
2. Calculate the mobility of MnO_4^- ions at the concentration of 0,015 M and write down the calculated value to the first row of the last column of the table 2.
3. In the table 2 there are also values of time of ion migration on the way of 0.5 cm, measured for solutions of 0,030M; 0,060M and 0,120 M concentration. Taking into account these data, calculate the mobility of ions for all the concentrations, at the voltage 20 V. Then plot the ion mobility versus concentration. Extrapolate the drawn curve to the concentration of 0 M and estimate the mobility of MnO_4^- ions for Infinite dilution. Write down the estimated value to the frame below the table 2.
4. Calculate the hydrodynamic radius of MnO_4^- ions (applying the formula from the theoretical part) – result should be written down to the frame on the bottom of the report sheet both in meters [m] and in Ångstroms [Å].

Required background in theory

1. Constant straight line movement:
   a. Definition, parameters of this movement and their units of measure
   b. Plots of the displacement and velocity versus time
   c. Estimation of an average velocity based on a plot displacement versus time
   d. Conversion of units of average velocity, for example: $mm \cdot s^{-1}$ to $km \cdot h^{-1}$
2. Description of a movement of a spherical object in a liquid phase, with a constant velocity:
   a. Resistance force (internal friction force, viscosity force)
   b. The Stokes law
3. Intensity (E) and potential (U) of the electric field, definition and units of these physical quantities. Relationship between the intensity and the potential of the electric field.
4. Movement of ions in the electric field:
   a. Electric force acting on an ion in the electric field, the formula
   b. Explanation of a difference between the average velocity of ion migration and the ion mobility
   c. Derivation of the formula for mobility of ion (u)
   d. Definition of the ion mobility for infinite dilution (u_0)
   e. Method of estimation of the (u_0)
   f. Derivation of the formula for a hydrodynamic radius of the MnO_4^- ion

Literature

1. Glaser „Biophysics", Springer, 2001.

Wrocław Medical University Department of Biophysics and Neuroscience	Practical No 11 Ion migration velocity

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Grade:	Tutor's signature:

Table 1.

Position	Distance [cm]	Time [s]

Average ion migration velocity: $\left[\frac{cm}{s}\right]$

Table 2.

$KMnO_4$ concentration [M]	Time [s]	Mobility [$cm^2V^{-1}s^{-1}$]
0,015	-	
0,030	284	
0,060	309	
0,120	340	

Ion mobility at infinite dilution:

Hydrodynamic radius of ion:

[m]	
[Å]	

Viscosity of water [η] = $1{,}009 \cdot 10^{-3} [N \cdot s \cdot m^{-2}]$
Elementary electric charge = $1{,}602 \cdot 10^{-19} [C]$