

Degree of dissociation and reduction of freezing point (DIS)

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1 Implementation

1.1 Preparation

We controlled that all devices (digital thermometer, scale and thermistor) were switched on and working correctly.

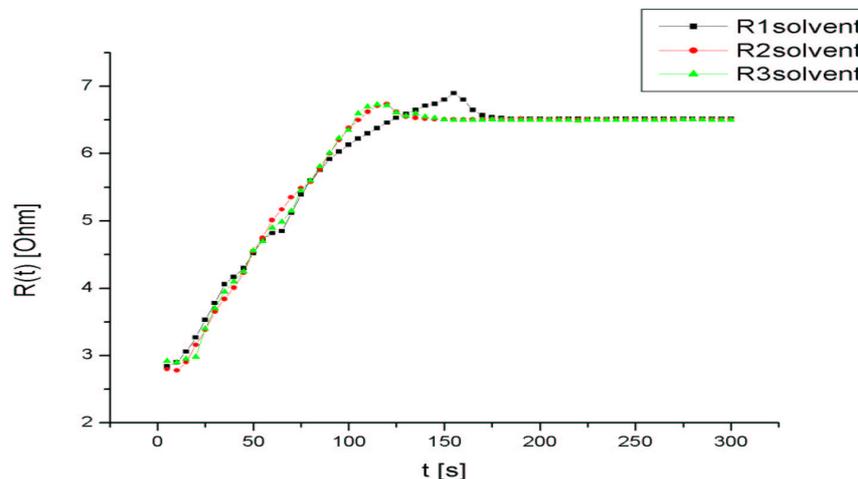
In this experiment, we had to determine the mass of substances in a test tube. Therefore we measured the weight of the test tube alone which we subtracted from measured masses of the test tube containing substances to gain the mass of the substance.

The mass of our test tube was 76,0 g.

To produce the freezing bath we completely filled a tub with ice, water and salt and mixed it by stirring. With the digital thermometer we controlled the temperature which had to lie below -6°C .

1.2 Determination of the freezing point of the solvent

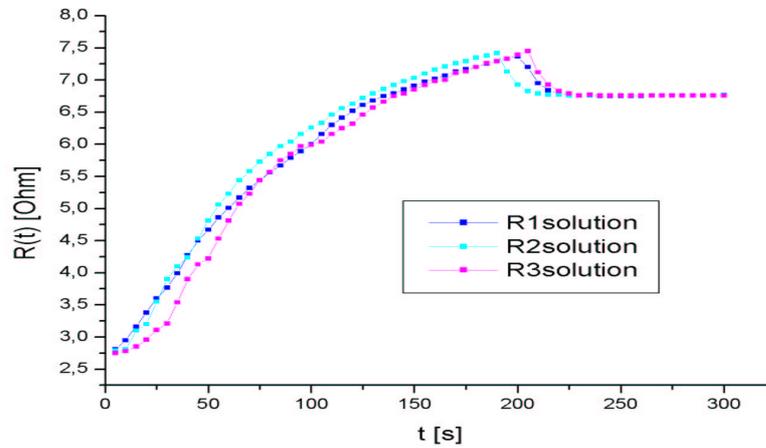
We filled the test tube with 20g of distilled water (mass of the test tube containing the solvent: $m(R1)=96,3\text{g}$; $m(R2)=95,7$; $m(R3)=96,0\text{g}$). The test tube with the solvent is put into the freezing bath and the thermistor is inserted into the test tube (sensor dipped into the solvent). With continuous stirring of the freezing bath and the solvent, we noted down the resistance R of the thermistor in 5s intervals.



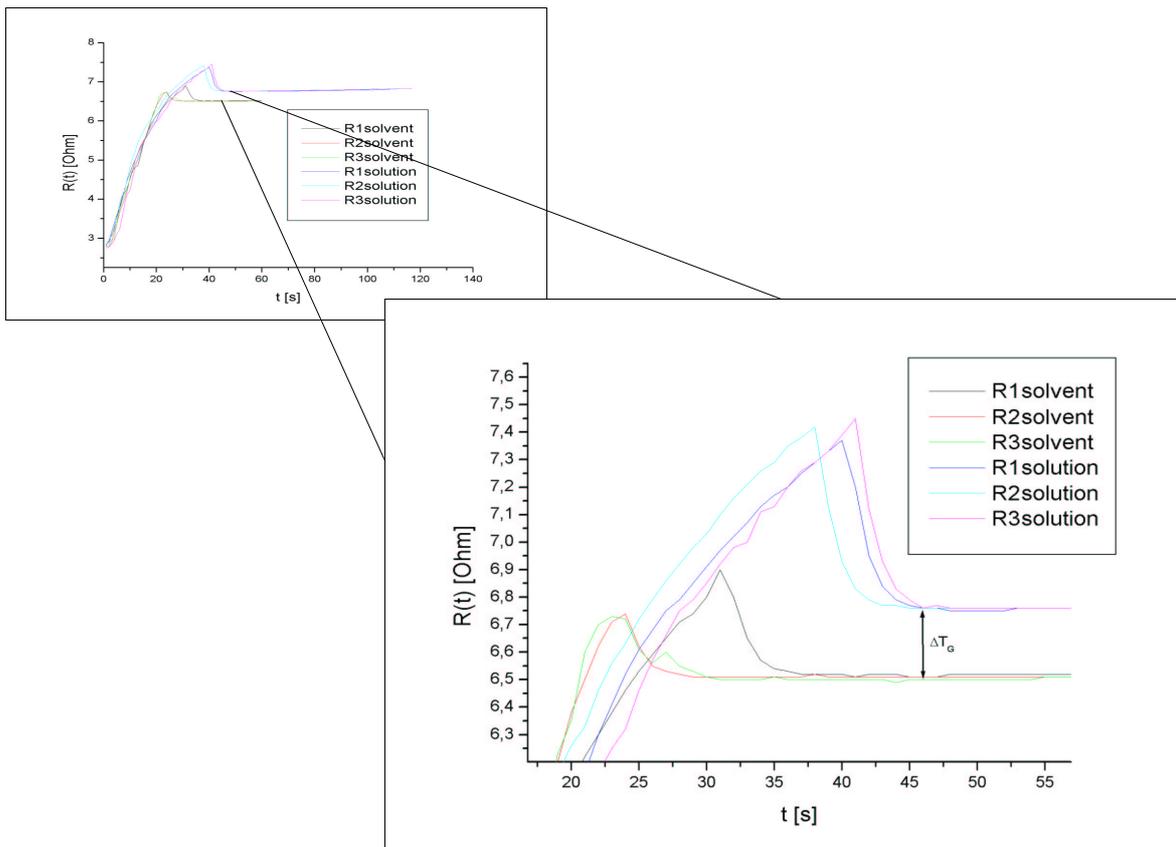
As can be seen in the graph, the R1 solvent curve has a quite different course than the two other curves. It is very likely that this „error“ is due to an irregular stirring of the freezing bath or the solvent. This leads us to the decision that calculating the mean value of resistance R for each time value t and plotting one graph gives us useless data (actually, a distorted curve). Because for our calculations, where only the difference ΔT_G of the two freezing–points is needed, we won't plot the graph of the mean values.

1.3 Determination of the freezing point of the solution

As for the solvent, we filled the test tube with 20g of distilled water (mass of test tube containing the solvent: 96,3g) and added 0,5g of kalium nitrate (mass of the test tube containing the solution: 96,8g). The mass of the solution was therefore 20,8g. The process of the measurement was exactly the same as in 1.2.



1.4 Calculation of temperature difference ΔT_G



To get the most exact value of the freezing points we calculate the mean values of the three measurements.

$$\Delta T_G' = (6,76 \pm 0,01) - (6,51 \pm 0,01) = (0,25 \pm 0,01)$$

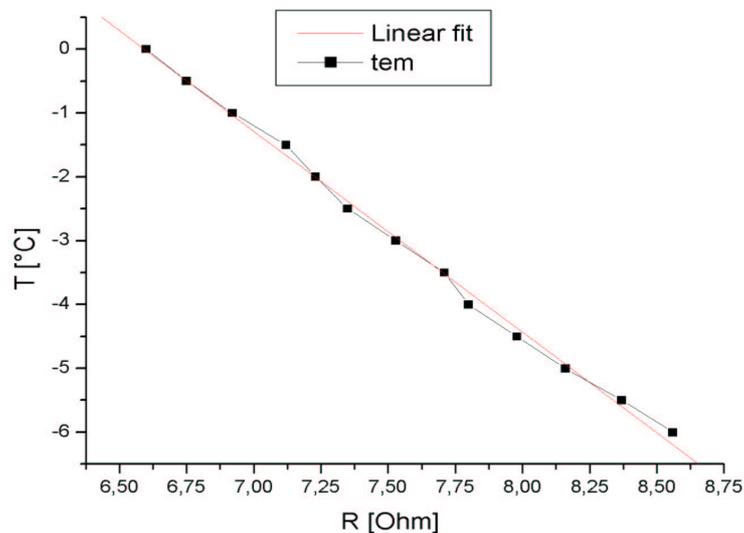
With respect to the calibration on 1.5, we can calculate ΔT_G from $\Delta T_G'$.

$$\Delta T_G = |(-3,14 \pm 0,05) * (0,25 \pm 0,01)| = (0,79 \pm 0,05)$$

	R1	R2	R3	\bar{R}	σ	u
solvent	6,52	6,51	6,50	6,51	0,01	7,60E-003
solution	6,75	6,76	6,76	6,76	5,77E-003	4,39E-003

1.5 Thermistor calibration

To calibrate the thermistor resistance with the correct temperature values, we created another freezing bath. The temperatures we measured reached from -6°C to 0°C . During the measurement, we permanently stirred the freezing bath. We noted down the corresponding thermistor resistance to the temperature values in $0,5^\circ\text{C}$ intervals.



The output of the mathematics program showed the following equation for the linear fit:
 $T(R) = (-3,14 \pm 0,05) * R + (20,68 \pm 0,41)$

1.6 Number of dissolved particles

$$M_1 = M(\text{H}_2\text{O}) = 18,0 \text{ g/mol}$$

$$K_{Gl} = 1,86 \text{ K/mol}$$

$$n_1 = m_1 / M_1 = 20,3\text{g} / 18,0 \text{ g/mol} = 1,1 \text{ mol}$$

$$n'_2 = \frac{n_1}{\frac{K_{Gl} \cdot 1000 \text{ g}}{\Delta T_G \cdot M_1} - 1} = (0,008 \pm 0,001) \text{ mol}$$

$$\text{Number of particles: } n'_2 * = n'_2 * 6,024\text{e}23 = (4,8 \pm 0,4)\text{e}21$$

1.7 Degree of dissoziation

$$m_2 = 0,5\text{g}$$

$$M_2 = M(\text{KNO}_3) = 101,1 \text{ g/mol}$$

$$n_2 = m_2 / M_2 = 0,005 \text{ mol}$$

$$n'_2 = (0,008 \pm 0,001) \text{ mol}$$

$$z = 2 \text{ (because } \text{KNO}_3 \rightarrow \text{K}^+ + \text{NO}_3^- \text{)}$$

$$\alpha = \frac{(n'_2/n_2) - 1}{z - 1} = (0,7 \pm 0,1)$$

1.8 Questions

1.8.1 What do you understand by an ideal solution?

You speak of a diluted solution, if the share of dissolved molecules is so small, that they almost never meet each other. That's why the reciprocal action between the dissolved molecules and the rest of the solution isn't influenced by other dissolved molecules. This state is reached if the part of dissolved molecules is below one percent. The solution is called ideal, if there are so few dissolved molecules, that there is absolute no influence as described above.

1.8.2 Why electrolytes aren't ideal solutions even in case of a high level of attenuation?

If electrolytes are dissolved, ions are created. The coulomb forces between the ions cannot be ignored no matter how high the degree of attenuation is.

1.8.3 Which units are used in common for concentrations?

- **fraction of moles (de: Molenbruch):** ratio of the quantity of the dissolved substance to the overall quantity of the substance
- **molality (de: Molalität):** quantity of the dissolved substance per kg of the solvent
- **molarity (de: Molarität):** quantity of the dissolved substance per liter of the solution

1.8.4 How is dissociation created ?

Dissociation is the process of polar solvents being arranged spherically around the ions, which has the effect of the ions being separated.

1.8.5 What do you understand by the degree of dissociation? How can it be determined?

The degree of dissociation is the ratio between the number of dissociated molecules and the number of all molecules. It can be determined by measuring the electrical resistance of the solution or over the decrease (increase) of the freezing point (boiling point).

1.8.6 Why is the vaporizing pressure of a solution of salt smaller than the vaporizing pressure of the solvent alone?

The vaporizing pressure of a solution is the ratio of the sum of the partial pressures of each substance to the fraction of moles. Because the vaporizing pressure of salts is approximately zero, the vaporizing pressure of the solution decreases by adding a salt.

1.8.7 How you can see from equation 4, that the melting pressure curve is steep?

The difference of the volumes $V_{\text{flüssig}} - V_{\text{fest}}$ (molarity volume of the solvent in a liquid respectively solid state) is very small, therefore the curve of the melting pressure graph dP / dT is steep.

1.8.8 Explain the way how a freezing bath works. Why does the ice-water-mix cool down, if salt is mixed in? Is it possible to use another salt?

When extracting ions out of the grid, dissociation energy has to be provided. This energy is freed by the arrangement of polar solvent molecules around the produced ions. It is also called solvation energy. The difference of the dissociation energy and the solvation energy is the "solution warmth". Depending on which one is higher, the "solution warmth" is endotherm or exotherm. By adding salt to the water endotherm "solution warmth" is freed and the solution cools down. Other salts with an equivalent endotherm "solution warmth" can be used in our experiment.

1.8.9 Why is the change of the electrical resistance with temperature of semiconductors higher than that of metals.

This behaviour can be explained with the band model. The conduction band of metals contains electrons at any temperature. This is the reason for the small electrical resistance. The conduction band of semiconductors is empty at a temperature of 0 K and is filled up with electrons as temperature increases. So the resistance depends highly on temperature.

1.8.10 What is meant by „negative temperature coefficient of the thermistor“?

Negative temperature coefficient means, that the electrical resistance of the thermistor decreases when temperature increases.