LABORATORY 4

SOLUTIONS AND THEIR PROPERTIES

I. Real solutions

1. Preparation of $CuSO_4$ solution with specific percent concentration

Procedure:

To prepare 25 or 50 mL of 10% (m/v) $CuSO_4$ solution students should:

● calculate, how many grams of hydrated salt ($CuSO_4$ x 5 H_2O) are needed to weigh (mol. mass of $CuSO_4$ – 160 g/mole; H_2O – 18 g/mole)

● weigh proper amount of salt (on a technical balance)

● transfer the weighed amount of salt to a beaker and dissolve it in a small amount of water. Stir a solution with a glass rod, transfer to a proper vessel (measuring flask for 25 or 50 mL) and fulfill with water to the exact volume. Keep the solution to the next experiment.

- *Express the concentration of the prepared solution in other units: moles/L, mole fraction of a solute and mole fraction of a solvent (density of 10% $CuSO_4$ – 1.05 g/mL).*

2. Dilution of 10% (m/v) $CuSO_4$ solution

During dilution of concentrated solution, a relationship between the concentration of a solution (percentage or moles/L) and its amount (grams, mL or L) is used. The amount of moles of solute (n) doesn't change during dilution.

$$C_1 \times V_1 = C_2 \times V_2$$

$$n_1 = n_2$$

Procedure:

Prepare 3 test tubes in a test-tube stand. Pour 1 mL of 10 % $CuSO_4$ to the first test tube and 1 mL of water to the next two test tubes. Then add 1 ml of 10 % $CuSO_4$ to the second test tube and mix. Transfer 1 mL of this solution to the third test tube and mix.

- *Observe the colours of prepared solutions*
- *Calculate concentration of solutions in the second and third test tubes (percent concentration (m/v) and molarity (mol/L)).*
- *Express a degree of dilution in the second and third test tubes in relation to the first test tube.*

II. Colloidal solutions

1. Preparation of hydrophilic colloid (gelatin solution)

Procedure:

Put a pinch (small amount) of **gelatin** to a beaker (with a volume 50 mL) and add 3 mL of water. Mix a solution with a glass rod and leave for 2 – 3 min for swelling. Then add 10 mL of water and heat it on kaolin plate with continuous stirring until full dissolving of gelatin. Cool the beaker with clear gelatin solution under running tap water.

2. Preparation of hydrophobic colloid – sol of silver chloride with positive and negative charge

Procedure:

a) add 3 mL of 0.01 M $AgNO_3$ solution to a test tube, then pour slowly, mixing simultaneously, 2 mL of 0.01 M NaCl solution. Milky, opalescent sol of AgCl is formed.

b) add 3 mL of 0.01 M NaCl solution to a test tube, then pour slowly, mixing simultaneously, 2 mL of 0.01 M $AgNO_3$ solution. Milky, opalescent sol of AgCl is formed.

- *Explain what charge (negative or positive) have colloidal particles received in point a and b*

Attention! Keep colloidal solutions prepared in points **1** and **2** to the next experiments

3. Coagulation of hydrophilic and hydrophobic colloids

Procedure:

Add 2 mL of following solutions to two test tubes:

- sol of AgCl with positive charge **or** sol of AgCl with negative charge
- gelatin solution

Add small equal portions of ammonium sulphate $(NH_4)_2SO_4$ (in a substance) to each test tube (stirring continuously) until precipitate formation in one of the test tubes.

- *Explain what can be the reason of the observed effect*

4. Protective properties of hydrophilic colloids

Hydrophilic colloids (proteins, oligosaccharides) can play protective function with biological importance. Sparingly soluble compounds, e.g. uric acid, bile pigments and calcium phosphate are kept in a form of fine suspension because of colloid action.

Procedure:

Pour 1 mL of 0.01 M $AgNO_3$ to two test tubes and then add 5 drops of 0.01 M HNO_3. Add 1 mL of distilled water to the first test tube and 1 mL of gelatin solution (prepared previously at point 1) to the second test tube. Mix solutions and add drop by drop 2 mL of 0.01 M NaCl to both solutions.

- *Explain what can be the reason of the observed effect.*

III. Observation of osmosis and osmotic pressure (one per one group)

Procedure:

Prepare 20 mL of 40 % saccharose solution, pH = 4.5 (adjust proper pH with 0.01 M HCl solution; check pH with indicator paper) and add 4 – 5 drops of methyl red. Transfer colored solution to a dialyzing tube which will be closed with a cork with a thin glass tube. Fasten prepared dialyzing bag with the cork in a stand clamp. The bag should be immersed in a beaker with water. Mark an initial level of a solution in a tube in the cork. Observe a change in the level of the solution in the tube and a change of a color of saccharose solution.

- *Explain what was the reason of an increase in the solution level in the tube and the change in the color of the solution*.

Examples of problems:

1. 222 g of $CaCl_2$ were dissolved in 2 L of water. Calculate the freezing and boiling point of the solution and the osmotic pressure (in atm) exerted by this solution on semipermeable membrane (mol. mass of $CaCl_2$ = 111 g/mole). (Answer: b.p. = 101.53°C; f.p. = -5.58°C; osmotic pressure = 67.2 atm)
2. The blood freezes at -0.56° C. What is percent concentration (m/v) of NaCl solution, isotonic to the blood? (mol. mass of NaCl = 58.5 g/mole) (Answer: 0.88%).
3. There are two water solutions separated by semipermeable membrane: 1 % (m/v) KCl (molar mass 74.5 g/mole) and 1.8 % (m/v) urea (nonelectrolyte; molar mass 60 g/mole). Are these solutions isotonic? If not, decide what will be a direction of water molecules penetration through a membrane (perform proper calculations). (Answer: solutions are not isotonic; water penetrates towards urea solution).
4. Will red blood cells undergo hemolysis in the solution containing 0.29 g NaCl (mol. mass = 58,5 g/mole) and 2.5 g saccharose (mol. mass = 342 g/mole) in 50 mL at temp. 37°C ? (Perform proper calculations). (Answer: no).
5. What is percent concentration (m/v) of KCl solution isoosmotic with physiological solution of NaCl at room temperature. (Molar concentration of physiological NaCl solution = 0,15 moles/L). (Answer: 1.12 %).
6. Solution with osmotic pressure 16000 hPa contains 10 g of urea (mol. mass 60 g/mole), 20 g of a very weak acid (mol. mass 80 g/mole) and glucose in 1 L. What is glucose concentration in this solution if osmotic pressure was measured at 25°C ? (R - Universal Gas Constant - 83.13 hPa·l/K·mol). (Answer: 0.23 osm (moles)/L)
7. Osmotic pressure of the hemoglobin solution (with concentration 5 g of hemoglobin /100 mL) in 27°C is 18.33 hPa. Calculate molar mass of hemoglobin. R (Universal Gas Constant) = 83.13 hPa·l/K·mol. (Answer: 67934 g/mole).
8. 0.02 moles/L of protein (in form of electrolyte Na^+Pr^-) were subjected to dialysis in 0.2 moles/L NaCl solution (both solutions are separated through semipermeable membrane which is permeable for water molecules and Na^+ and Cl^- ions). Calculate concentrations of Na^+ and Cl^- in both compartments in Donnan equilibrium state. (Answer: concentration of ions in the compartment with protein: Na^+ = 0.115 moles/L, Cl^- = 0.095 moles/L; concentration of ions in the compartment without protein: Na^+ = 0.105 moles/L, Cl^- = 0.105 moles/L).