LABORATORY 5

SOLUTIONS AND THEIR PROPERTIES

I. Real solutions

1. Calculations of $CuSO_4$ concentration in a solution

- Calculate percent concentration (m/v) of $CuSO_4$ solution containing 2.5 g of $CuSO_4$ in 25 mL of the solution or 5 g of $CuSO_4$ in 50 mL of the solution
- Calculate molarity of this solution (mol. mass of $CuSO_4$ – 160 g/mol)
- Calculate mole fraction of a solute ($CuSO_4$) and mole fraction of a solvent (H_2O) in the solution with calculated concentration (density of $CuSO_4$ – 1.05 g/mL)

2. Dilution of $CuSO_4$ 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 5 test tubes in a test-tube stand. Pour 1 mL of $CuSO_4$ solution (with concentration calculated in point 1) to the first test tube and 1 mL of water to the next four test tubes. Then add 1 ml of $CuSO_4$ to the second test tube and mix. Transfer 1 mL of this solution to the third test tube and mix. Then, transfer 1 mL of the solution from third test tube to fourth test tube, and finally from fourth test tube to fifth one.

- *Calculate concentration of diluted solutions (percent concentration (m/v) and molarity (mol/L)).*
- *Express a degree of dilution in all test tubs in relation to the first test tube.*

II. Colloidal solutions

1. Hydrophilic colloid (ready-to-use 0.5 % gelatin solution)

Procedure:

0.5 g of gelatin was weighed out and solubilized in small amount of distilled water. Then the volume was made up with water to 100 mL and the solution was heated (in warm water bath) to completely dissolve gelatin.

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! Hydrophilic and hydrophobic colloidal solutions from points **1** and **2** will be used in the next experiments

3. Comparison of coagulation of hydrophilic and hydrophobic colloids

Procedure:

Prepare 2 test tubes. To the first add 2 mL of AgCl (prepared in point 2a or 2b) and to the second add 2 mL of gelatin. Then add small, equal number of drops of ammonium sulphate ($(NH_4)_2SO_4$) saturated solution to both test tubes (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 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*.

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^{o}C; f.p. = -5.58^{o}C; osmotic pressure = 67.2 atm)
2. The blood freezes at -0.56^o 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).