Subject 2. Ways of expression of quantitative composition of solutions

1. Importance

Blood plasma, saliva, gastric juice and other biological fluids in the organism are solutions. Processes of food assimilation and excretion are possible only in solutions. A great number of medical preparations are also solutions. Thus, it is important for a doctor to know values that characterize quantitative composition of solutions.

Competences

Capacity for analysis of information, capacity to make decisions.

Ability to apply knowledge in practical situations.

Ability to communicate in English both orally and in writing.

2. Concrete aims

Perform calculations for preparing solutions of given concentration;

Calculate the amount of solute in a solution of given concentration.

Perform calculations to transit from one form of concentration to another.

3. Basic knowledge, skills necessary for studying the subject (interdisciplinary integration)

Previous subjects	Obtained skills
1. Chemistry and Physics (school course)	Know composition of solutions and values that characterize their quantitative composition. Calculate the amount of a solute in a solution of given concentration. Use SI units.
2. Foreign language for professional purposes	Have perfect knowledge of English. Use English in professional and business communications and preparation of documents.

4. Tasks for independent work during preparation for the class and in class.

4.1. The list of key terms, parameters, characteristics which the student is to learn while preparing for classes:

Term	Definition
1. Solutions	**Solutions** are thermodynamically stable homogeneous systems of variable composition consisting of two or more components and products of their interaction.
2. Dilute solutions	In **dilute solutions** concentration of the solute does not exceed 30%.
3. Concentrated solutions	In **concentrated solutions** concentration of the solute is more than 30%.
4. Unsaturated solutions	**Unsaturated solutions** are those where some mass of

	the solute can still dissolve.
5. Saturated solutions	**Saturated solutions** are those where the amount of the substance that dissolves in a unit of time is equal to the amount of substance that is released as the solid phase.
6. Supersaturated solutions	**Supersaturated solutions** are those that contain more of the solute than is needed for saturation under the given conditions.
7. Mass fraction	**Mass fraction** is a ratio of the component (the solute) to the total mass of the system (the solution).
8. Molarity	**Molarity** is the ratio of the number of moles of the solute to the volume of the solution.

4.2. Theoretical questions for the lesson:

1. Composition of solutions.
2. Classification of solutions.
3. Values that characterize quantitative composition of solutions.
   3.1. Mass, volume and mole fraction.
   3.2. Molarity.
   3.3. Normality (deci-, santi--, milli- and micromols).
   3.4. Molality.
   3.5. Titr.

4.3. Practical work (task) done by students in class

Task № 1

0.040kg salt was dissolved in 0.200L water. Calculate the mass part of the salt in the solution, if the density of water is 1 kg/L.

Task № 2

Calculate the mass of 10% (by mass) $CuSO_4$ solution and the mass of water, which are needed to prepare 0.5 kg 2% (by mass) $CuSO_4$ solution.

Task № 3

Calculate the molarity of a sodium hydroxide solution with the mass fraction 0.2. The density of the solution is 1.29 kg/L.

Task № 4

Calculate the normality of a solution obtained by dissolving 0.0426 kg sodium sulfate in 0.3 kg water. The density of the solution is 1.12 kg/L.

Task № 5

Calculate the molality of a potassium chloride solution, if 0.5 kg of the solution contains 0.05 kg salt.

Contents of the subject (abstract):

1. Composition of solutions.

Solutions are thermodynamically stable homogeneous systems of variable composition consisting of two or more components and products of their interaction.

Components of the solution: the solvent and a solute (one or more).

2. Classification of solutions.

By the aggregative state:

- Gaseous
- Liquid
- Solid

By the amount of the solute:

- Dilute solutions are those where concentration of the solute does not exceed 30%.
- Concentrated solutions are those where concentration of the solute is more than 30%.

За здатністю речовини розчинятись розрізняють

- Unsaturated solutions are those where some mass of the solute can still dissolve.
- Saturated solutions are those where the amount of the substance that dissolves in a unit of time is equal to the amount of substance that is released as the solid phase.
- Supersaturated solutions are those that contain more of the solute than is needed for saturation under the given conditions.

Values that characterize quantitative composition of solutions

3.1. Mass, volume and mole fractions.

Mass fraction (ω) is the ratio of the mass of a component (the solute) to the total mass of the system (the solution). It is expressed in percents, promille, etc.

$$\omega\,(\text{solute}) = \frac{m(\text{solute})}{m(\text{solution})} \times 100\%$$

Mole fraction (χ) is the ratio of the number of moles of a component (ν solute) to the total number of moles in the system (ν solution). It is expressed in the same way as mass percent.

$$\chi_B = \frac{\nu_B}{\nu_A + \nu_B + \ldots \nu_i}$$

Volume fraction (φ) is the ratio of the volume of a component to the total volume of the system.

$$\varphi_B = \frac{V_B}{V_A + V_B + \ldots V_i}$$

3.2. Molarity.

Molarity (C) is the ratio of the number of moles of the solute ν to the volume of solution V. Molarity is measured in mol/L.

$$C = \frac{\nu(solute)}{V(solution)}$$

3.3. Normality

Normality (C_{equiv}) is the ratio of the number of moles of the solute ν_{equiv} to the volume of solution *V*. Normality is measured in mol/L.

$$C_{equiv} = \frac{\nu_{equiv}}{V},$$

where ν_{equiv} is the number of moles of equivalent of the solute, mol
V is the volume of the solution, L.

$$\nu_{equiv} = \frac{m}{M_{equiv}};$$

$$M_{equiv} = M \cdot f_{equiv};$$

$$f_{equiv} = \frac{1}{n},$$

where *n* is the number of ions H^+ in the molecule of an acid,
or the number of hydroxide ions OH^- in the molecule of a base,
or a product of the valency of a metal and the number of the metal atoms in the molecule of a salt.

The equivalent is the part of a substance (real or symbolic), which is equivalent to one mole of hydrogen atoms or one mole of hydrogen cations in reactions or one electron in redox reactions.

3.4. Molality.

Molality (C_m) is the ratio of the number of moles of the solute to the mass of the solvent.

$$C_m = \frac{\nu_{solute}}{m_{solvent}},$$

where *v* is the number of moles of the solute, mol
m is the mass of the solvent, kg.

3.5. Titr.

Titr (T) is the mass of the solute (g) in one mL of the solution.

$$T = \frac{m(\text{solute})}{V(\text{solution})}$$

Materials for self control:

A. Tasks for self control:

1. Choose the notion of a tridecimolar solution:

a) 3M;

b) 3N;
c) 3 dm^3;
d) 0.3M;
e) 30M.

2. Specify the characteristic features of solutions:
a) homogeneity;
b) heterogeneity;
c) only chemical interaction;
d) presence of physical and chemical interaction;
d) only physical interaction.

3. The solvent is:
a) the liquid component of the solution;
b) the more reactive component;
c) the component of the solution that has greater density;
d) the component of the solution which is in the same aggregate state as the solution;
e) the component of the solution that has ionic structure.

B. Calculation tasks for self control:

Task № 1.

Calculate the molality of physiological saline with mass percent of sodium chloride 0.85%.

Task № 2.

A water solution is obtained by dissolving 0.005 kg glucose (Mr = 180) in 0.095 kg water. It is isotonic to blood plasma. Determine mass fraction and molarity of glucose in the solution.

Task № 3.

Calcium chloride (Mr = 111) solution is used for treatment of allergic and skin diseases. Its titr is 0.0999 g/ml. Calculate molarity and normality of calcium chloride in the solution and their correlation.

Literature

Main:

1. Medical Chemistry: textbook / V.O. Kalibabchuk, V.I. Halynska, V.I. Hryshchenko et al.; edited by Prof. V.O. Kalibabchuk – Kyiv: "Medicine", 2010 – 224 p. (P. 58 – 60).

Informational resources:

2. www. pdmu, edu.ua
https://med-chemistry.pdmu.edu.ua/

(Web page of Poltava State Medical University).