Subject 3. Preparation of solutions with known quantiatative composition

1. Importance

Solutions with molecular and ionic dispersion of solute – true solutions – are the most important representatives of biological fluids. Water solutions of electrolytes and low molecular substances ensure constant osmotic pressure, buffer properties of biological fluids, membrane potentials, enzyme activity etc.

Changes of composition of biological fluids are manifestations of diseases. Thus, a student must know basics of the theory of solutions and be able to prepare needed solutions in order to learn biological chemistry and pharmacology.

Competences

Ability of abstract thinking, analysis and synthesis, ability to learn.

Ability to apply knowledge in practical situations.

Ability to use English language in professional and business communications and preparation of documents.

Ability to choose strategy of communication; ability to work in a team; skills of interpersonal interaction.

Ability to excercise self-control and maintain healthy lifestyle, ability to adapt and act in new situations.

Motivation and persistence in following goals.

Skills in using information and communication technologies.

Ability to assess and ensure quality of performed work.

Strive to preserve the environment.

Ability to assess results of laboratory and practical experiments.

Ability to solve standard problems and to solve practical problems in the course of training.

2. Concrete aims

Be able to calculate the amount of the solute and solvent to prepare a solution of given concentration.

Prepare solutions of given concentration.

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

Previous subjects	Obtained skills
1. Foreign language for professional purposes	Possess basic knowledge of English language. Be able to communicate in English language. Use English language in professional activity.
2. Latin language and medical therminology	Master medical therminology in Latin language.
3. Medical Biology	Know structure components of cytoplasm and nucleus.
4. Safety, basics of bioethics and biosafety	Be able to exercise self-control, healthy lifestyle, be able to adapt to and act in new situations. Strive to protect the environment.

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. Solubility	An ability of a substance to dissolve in a solvent.
2. Solubility coefficient (k_s)	Grams of a substance that can be dissolved in 100 g of the solvent at given conditions.
3. Solutions	Homogeneous thermodynamically stable systems of variable composition that consist of two or more components and products of their interactions.

4.2. Theoretical questions to the lesson:

1. Solutions in life.
2. Enthalpy and entropy factors of dissolution, their relationship with the mechanism of dissolution.
3. Solubility of gases in liquids and its dependence on various factors. Henry-Dalton's law.
4. Effect of electrolytes on the solubility of gases (Sechenov's law). Solubility of gases in blood. The caisson disease.
5. Solubility of liquids and solids. Distribution of substances between two immiscible liquids. Nernst's law and its importance for explanation of permeability of biological membranes.
6. Preparation of solutions of given concentrations.

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

1. Preparation of solutions from fixanals.

To prepare a solution of a fixanal it is necessary to transfer the contents of the ampule into a volumetric flask and make to the mark with distilled water. The procedure: remove the label off the ampule, wash the ampule thoroughly and rinse it with distilled water. Take a needed volumetric flask (1.0, 0.5, 0.25L); insert a 9-10 cm diameter funnel into it. Place a beater inside. Hold the ampule vertically, and pierce it with the beater from one side. Use another beater to pierce the ampule from the other side and let the contents pour into the flask. Without changing the position of the ampule wash it thoroughly with distilled water. Take six or more volumes of water for the volume of the ampule. Then make the flask to the mark with distilled water and mix thoroughly.

2. Preparation of solutions of given concentrations with calculated weight of solute.

Every student receives a card with a task to prepare a solution of a medical preparation with certain concentration and explanation of its application. The

students make calculations and then prepare the solution after checking the results with the teacher.

Preparation of solutions with mass concentrations. Weigh out the calculated mass of substance on technochemical scales, place into a retort and add the calculated volume of water. Mix until completely dissolved.

Preparation of solutions with given molarity and normality. Weigh out the calculated mass of substance on analytical scales (pipet the liquids) and transfer carefully into a volumetric flask (first add some distilled water to the flask). Dissolve the substance in the water then make to the mark with distilled water. Mix the solution.

3. Writing a report of the laboratory work:

Make the necessary calculation and describe preparation of the solution in the notebook according to the individual task.

Contents of the subject (abstract):

1. **Solutions in life.**

Solutions are the most common systems in nature. They play a vital role in living organisms. Water is the universal solvent of solid, liquid and gaseous substances. Water solutions are the environment in which the majority of chemical reactions, including a variety of physiological and biochemical processes in living organisms (digestion, absorption of blood nutrients and excretion of harmful metabolic products, etc.) proceeds. The main biological systems blood plasma, lymph, urine, cerebrospinal fluid contain various dissolved inorganic and organic substances. In particular, blood plasma consists of water (90 - 92%) and dry matter (8 - 10%).

2. Enthalpy and entropy factors of dissolution, their relationship with the mechanism of dissolution.

Dissolution is a spontaneous process that is accompanied by an increase of randomness of particles in the system. Its characteristics are an increase in entropy ($\Delta S > 0$) and a decrease in the Gibbs free energy ($\Delta G < 0$). Chemical thermodynamics states that

$$\Delta G = \Delta H - T\Delta S$$

The equation shows that if $\Delta H < 0$ and $\Delta S > 0$, then $\Delta G < 0$ and at any temperature the process occurs spontaneously.

ΔH-entalpic factor;

ΔS-entropic factor.

3. Solubility of gases in liquids and its dependence on various factors. Henry-Dalton's law.

Non-polar gases are difficult to dissolve in polar solvents, including water. They are more soluble in nonpolar organic solvents. Solubility of gases depends on temperature, pressure, presence of electrolytes. As temperature increases solubility of gases decreases.

Henry's law: solubility of a gas in a liquid is directly proportional to its pressure above the liquid:

$$m = kp$$

where m is the mass of the dissolved gas;

p is the pressure of the gas above the liquid;

k is the proportionality factor that depends on the identity of the gas.

The first law of Dalton: the total pressure of the mixture of gases that do not interact with each other is the sum of all partial pressures of its components.

$$p_{total}=p_1+p_2+\ldots p_i$$

The second law of Dalton: solubility of each component of a gas mixture in a liquid at a constant temperature is directly proportional to its partial pressure above the liquid and is independent of the total pressure of the mixture and amounts of other components.

$$m_i=k_i\ p_i$$

where m_i is the mass of each component of the gas mixture dissolved in the solution;

p_i is the partial pressure of each component of the gas mixture.

4. Effect of electrolytes on the solubility of gases (Sechenov's law). Solubility of gases in blood. The caisson disease.

Solubility of gases in electrolyte solutions is lower than than that in the pure solvent (Sechenov's law). The relation is expressed mathematically by the equation

$$S=S_0e^{-kc}$$

where S is solubility of a gas in an electrolyte solution with concentration C (mol/dm^3);

S_0 is solubility of a gas in water;

k is a constant that depends on temperature and the nature of components of the solution;

e is the base of natural logarithm.

An increase of the amount of oxygen in blood facilitates carbon dioxide release from blood and, conversely, increased pressure of carbon dioxide increases solubility of oxygen in blood.

Concentrations of gases in blood increase deep under water due to increased pressure. Upon a rapid lifting of divers from the depth, a sharp decrease in pressure causes rapid release of dissolved gases in blood. The resulting bubbles clog capillary blood vessels (gas embolism), and the disrupt of blood supply that can cause serious functional disorders. Therefore, to prevent decompression sickness a diver should be raised to the surface slowly.

5. Solubility of liquids and solids. Distribution of substances between two immiscible liquids. Nernst's law and its importance for explanation of permeability of biological membranes.

Nernst distribution law: at constant temperature the ratio of concentrations of a substance that is distributed between two immiscible liquids is a constant value.

$$K_{distr}=C_1/C_2\ ,\ \text{where}$$

K_{distr} is the distribution coefficient;

C_1 is the concentration of the solute in the first solvent;
C_2 is the concentration of the solute in the second solvent.

Transport of substances through cell membranes can be explained by the law of distribution. Thus, water-insoluble non-polar substances (fatty acids, fats, cholesterol, etc.) flow into the cell by dissolving in the lipid layer of the membrane. They are difficult to dissolve in water, and their accumulation in the lipid layer of the membrane is subject to the law of distribution.

Materials for self control:

A. Tasks for self control:

1. When ammonia nitrate is being dissolved, the solution is colder than the air. When sulfuric acid is dissolved, the solution is hotter than the air. Why?

2. Why must a diver rise gradually and slowly, not fast from the big depth?

B. Calculation tasks for self control:

1. To measure concentration of potassium ions in the saliva with the flame photometry method it is necessary to prepare 0.25 L of a solution, which contains 0.04 mmol/L potassium cation and 0.64 mmol/L sodium cation. How to prepare the needed solution, if there is a 1 mmol/L potassium chloride solution and 2 mmol/L sodium chloride solution.

2. Calculate the volume of 9.3% (by mass) sulfuric acid solution (density 1.06 kg/L), needed to prepare 0.05 L of 0.35 *N* sulfuric acid solution.

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. 60 – 62).

Informational resources:

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

(Web page of Poltava State Medical University).