



**Problems of VI International Natural Sciences Tournament
11-16 November 2015, Saint Petersburg, Russia**

Version 3, 11.10.2015. Contains 15 problems divided into 3 units.

Unit X*

Alpechin

After the extraction of oil from olives there remains a liquid, which is called "alpechin" in Spanish. Most often, having found no better way to use it, alpechin is simply evaporated in the sun, and some dishonest manufacturers even dump it into rivers. This harms the environment because alpechin contains toxic phenolic compounds, and the annual volume of its production worldwide is about 30 million tons.

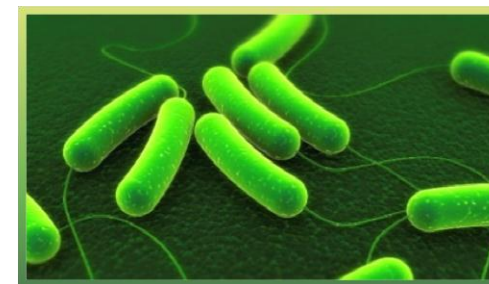
Propose an economically advantageous way to use alpechin, or a method of its disposal, which would be affordable by price and labor effort for small businesses that produce olive oil.



Bacteria on a leash

Currently, scientists are actively researching the possibility of creating new microorganisms for use in industry and agriculture (e.g. for microbiological synthesis). However, in everyday life (in an apartment, office, store...) people are rarely confronted with deliberate use of microorganisms.

Propose a new method of using microorganisms in everyday life, that is, in your opinion, the most attractive for implementation. Prove its feasibility, evaluate the expected benefits and risks.





To protect from sun protection

Every year about 6 thousand tons of sunscreen is washed away into the seas. In most cases, microcrystalline titanium dioxide is used as an UV filter in such creams, which is considered to be biologically harmless. However, in seawater, when titanium dioxide is exposed to sunlight, reactive compounds are formed and kill phytoplankton, which serves as food for fish.

Propose an effective UV filter in the form of a microcrystalline inorganic powder that would be safe both for humans and for marine life.



Pure membrane – pure water

Hollow fiber membranes used in modern household water purification devices, such as "Aquaphor-Eco", are a set of hundreds of porous microtubes with a pore size of about 0.1 microns. During exploitation, the membrane pores, under certain conditions, may become stopped with filtered colloidal particles and bacteria long before the exhaustion of the capacity of other modules.

Suggest a method (device, scheme, reagent etc.) which significantly extends the resource of the membrane, is safe for the user and does not affect the quality of the entire filter.

The increase in the cost of the module due to the proposed modification should not exceed 10 euros. Simply increasing the area of the membrane cannot be considered a solution.





Mission Impossible

In the movie "Mission Impossible" secret agent Ethan Hunt (Tom Cruise) uses a device disguised as chewing gum, which is basically a half-red half-green stick. When these halves are combined, an explosion occurs after 5 seconds.

Based on this principle of operation, make up the composition of your own similar "chewing gum", which will not explode when activated, but will evolve enough heat to:

- 1) warm up a frost-jammed padlock at the temperature of -20°C
- 2) light a fire in field conditions

Is it possible to create a "chewing gum" suitable for both problems at the same time? For what other purposes one may use such a device?

The heating "gum" you propose should:

- be the same size and shape as a standard stick of gum.
- be activated by combining its two parts; its usage should not require any additional devices or materials; it should not release toxic gases.
- be safe when stored in package wrapping under normal conditions (in your pocket) and have a shelf life of at least 1 year.





International Natural Sciences Tournament, 2010-2015

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Unit Y*

Methanol

It happens that dishonest producers of windshield washer fluids replace isopropanol with less expensive, but more hazardous to health methanol without notifying the consumer about it in any way. Methanol poisoning can lead to blindness and even death.

Propose a simple and rapid test method for detecting methanol in windshield washers in the presence of isopropanol and/or ethanol. The method should be accessible for a common motorist without special education. Can your method be used for detecting methanol in other practically important systems?



Stop the pine shoot beetle

In North America, there is a problem with pine shoot beetles, which destroy pine forests on huge areas. Suggest an economically feasible and environmentally safe method of saving forests from these pests.





Flow reactor

One of the most advanced technological solutions in the modern pharmaceutical industry is the use of micro- and meso-channel continuous-flow reactors. Such reactors are systems of serially connected modules, each of which has a small cross section channel for the continuous flow of reaction mass, surrounded by space for the heat transferring liquid. These systems can significantly increase the product yield and reduce the process duration compared to conventional batch reactors.

The reaction of 1,4-butanediol mononitration is carried out in a batch reactor with following parameters:

- Reactor volume: 1 m³
- Organic phase volume: 0.5 m³
- Concentration of 1,4-butanediol in the solvent (dichloromethane): 2.3 wt. %
- Concentration of HNO₃ in water: 60 wt. %.
- Operating temperature: 10 – 70 °C
- Mixing duration: 2.5 hours
- The process is stopped in order to avoid the formation of the dinitro- product

Suggest a schematic diagram of a flow reactor system for this process. Define and justify the optimal system parameters: the minimum number of necessary modules, their temperature, the flow rate. What other factors should be considered when designing such a system? Evaluate the expected benefits of using your flow system as compared to the use of the batch reactor.

The working volume of one flow module is 10 ml, the overall flow rate must not exceed 200 ml/min, the maximum pressure - 18 bar.

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A cloudy story

The MEL Science company produces chemistry sets for children to do scientific experiments at home. One of the thematic sets is devoted to tin and includes two experiments with SnCl_2 solution: the growth of tin strands by electrolysis ("Tin dendrite") and the growth of tin crystals on a zinc granule ("Tin hedgehog").

For user convenience, MEL Science supplies tin chloride as a 0.5 M solution, which is prepared as follows. A sample weight of crystalline SnCl_2 hydrate is dissolved in 0.5 M hydrochloric acid, which serves to suppress the SnCl_2 hydrolysis. As a result, a cloudy solution is formed, which is filtered. The obtained clear solution is poured into 10 ml polypropylene vials using a dispenser and then hermetically sealed.

For the experiments to be spectacular, the SnCl_2 solution should remain clear until the set is delivered to the customer, i.e. at least 2 months. However, in some cases, opacity of the solution is observed already after one week after sealing. It has been found that the rate of opacity appearance of the solution is different for samples of tin chloride, which have the same purity grade, but were purchased from various suppliers. What can this be due to? What factors can affect the rate of turbidity appearance of SnCl_2 solution under described conditions? Suggest a way to avoid this unwanted turbidity.

Drops

When drops fall onto an oscillating liquid layer, they may remain on the surface up to several minutes without merging with the layer of liquid. This effect can be observed on a special vibrating table, as well as in the process of distillation, filtration or simply by dripping liquid from a certain height and with a certain speed.

Explain this phenomenon, determine the conditions under which it occurs, and, most importantly, propose a practical application for this phenomenon.



Unit Z*

The Captain's pearl

«I estimated the weight of this tridacne at 600 lb... between the folded plaits, I saw a loose pearl, whose size equalled that of a coco-nut. Its globular shape, perfect clearness, and admirable lustre made it altogether a jewel of inestimable value»

– Jules Verne, *Twenty Thousand Leagues Under the Sea*

The largest pearl ever found is close to this description - it weighs about 6.4 kg, its length is 23.8 cm. However, it is of irregular shape and does not have the characteristic pearl luster. What factors affect the size and quality of a pearl during its growth? Propose a way to produce such large and high-quality pearls, as described by Jules Verne. The pearls should be whole and consist of real nacre.



Gel pressure sensor

There are colored gel pads for controlling pressure distribution. Areas that are longtime exposed to higher pressure become lighter, and after some time the pad is restored. Today these pads are used to choose sports equipment, for example, saddles in equestrian (the «impression pad»). However, they are quite expensive and not widely available.

Where else gel pad-sensors with such operation principle could be used? Propose a method to produce them at home.

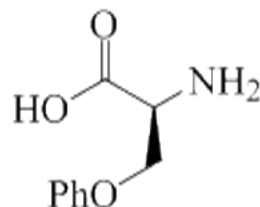




Serin

Natural amino acids are part of a large number of active pharmaceutical substances, so obtaining various amino acid derivatives is an important synthetic challenge. Offer a cheap and easily scalable method of synthesizing O-phenyl-L-serine from unsubstituted natural serine.

What side reactions should be avoided and how is the choice of the used protecting groups motivated?



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Fake milk

Counterfeit of natural milk is a serious problem in developing countries. Drinking adulterated milk is harmful and can lead to serious health problems when given to children.

What are the ways of counterfeiting milk? Suggest a method of analyzing milk, which would allow to distinguish between the natural product and the counterfeit. The method should be affordable for household use by people in developing countries.





Glycol**

Glycols form the base of heat transferring fluids used in food factories for cooling products during the manufacturing process. These coolants have a long, though finite, service life. After some time, due to the deterioration of operational properties, the user is confronted with the problem of utilization. Currently, methods of combustion and microbial decomposition are used for this purpose. Each of them has its own weaknesses and harms the environment. The volume of the coolant, which has to be recycled simultaneously, depends on the production capacity and typically is tens of tons.

Propose an economically feasible method of disposing glycol-containing heat transferring fluids, which will improve the technology of handling this type of waste and reduce the negative impact on the environment compared to the already known approaches.

CLARIANT 

* The problems are divided into units X, Y and Z. Each unit corresponds to a certain tournament day. On what day each unit will be played, will be announced at **three days before the tournament start**. Please, be careful to work through each problem. Remember, that you may refuse to solve any one problem in each block.

** The team with the best solution of this problem will be awarded a visit to the Clariant laboratory in Europe. For more information about this contest, ask the organizing committee or visit our website www.scitourn.com