

Grand final
X International Natural Sciences Tournament
February 6-12, 2020
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participants@scitourn.com

Problems of the Grand final of X International Natural Sciences Tournament

Unit X

1. Smoggy coal

In Poland, it is common to heat private houses with coal and solid fuel. This leads to the formation of smog causing troubles for dozens of thousands of people according to the World Health Organization. A long-term solution of the problem is switching to other energy sources but time is required to build an infrastructure. Suggest a short-term solution for a single house to minimize effects of heating with coal on smog formation.

2. Glitter (*Krastsvetmet*)

Rhodium plating, i.e. coating with a thin layer of rhodium, is one of the ways to give silver alloys used for jewelry a better resistance to darkening during usage. The most common alloy composition is silver and copper in weight ratio of 37 to 3. However, even though rhodium plating is widely used, this method is insufficient – over time, rhodium-plated silver darkens when worn or used. Suggest an alternative way to make silver products that will not darken when used. Economic efficiency must be taken into account.

3. *Rhinella marina*

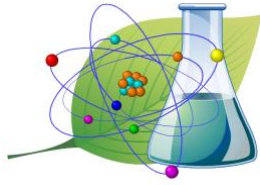
Cane toad, or *Rhinella marina*, was artificially introduced to Australia 80 years ago and since then its population has reached 200 million specimens and keeps growing. All body parts of cane toad are poisonous, causing not only economical, but also ecological damage. Nowadays the most effective but time-consuming method against *Rhinella marina* is simply trapping it manually. Offer cost-effective technology for controlled reduction of the species population in Australia with its further maintenance at a safe or low level. Minimize the possible impact of your proposed method on the Australian eco-system.

4. Bioremediation

A unique bacterium was found around Japanese plastic-recycling factory in 2016. It was *Idenella sakaiensis*, a bacterium capable of breaking down and consuming plastic by means of an enzyme called PETase. Suppose the mechanism of chemical transformations of plastic processing based on such enzymes. The proposed mechanism must meet the following requirements: there should be no toxic compounds at any stage; end products are biodegradable.

5. Vostok

Lake Vostok is the largest and deepest subglacial lake in Antarctica. Obtaining samples from this lake could shed a light on the evolution of life on the Earth and be a model system for getting subglacial samples from other celestial bodies. However, there is a high chance of contaminating the lake while taking up samples. Scientists managed to investigate only



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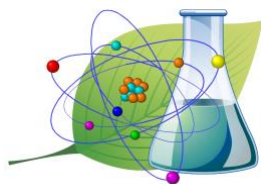
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periglacial layer, but such samples cannot be considered as representative due to possible living activity in the lake since the conditions on the bottom and on the periglacial layer can differ quite drastically. How to carry out sampling from the bottom of the lake Vostok without contaminating it? Is it possible to use the method you suggested for experiments in space?

6. Cell spheroids (Geropharm)

Since regenerative medicine for organs and tissues with the use of 3D-printing techniques is on the rise, scientists use cell spheroids – systems containing 4 up to 8 thousand cells. This range stems from the fact that if there are more than 8k cells the “core” of the spheroid will not get enough nutrients and cells start to die; if there are less than 4k cells, then it would be highly inconvenient to carry out bioprinting. Spheroids are usually formed in special agarose plates, though it is hard to extract spheroids from them later on. Manufactured plates are quite expensive, as well. The drawback of microencapsulation, another way of spheroid formation, is that microcapsule’s wall has a bigger diameter than cell spheroid itself. Suggest an alternative available method or improve one of the existing methods to produce a cell spheroid containing a specified number of cells.



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Unit Y

7. **Sunken Franken**

The oil tanker “Franken” lies on the bottom of the gulf of Gdansk and the Baltic Sea is in ecological danger due to the fuel on broadside of the tanker. The existing approaches to deal with this problem such as defueling or lifting the ship are rather expensive and technically complicated. Suggest another method and compare it with the existing methods.

8. **Forever together (Krastsvetmet)**

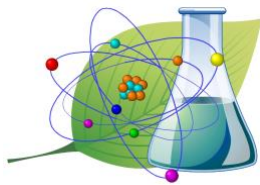
Iridium, rhodium, ruthenium, and osmium are called satellite metals due to their presence in small quantities in platinum and palladium ores. These metals have found their use in many industrial fields if being properly separated from each other. Suggest an industry- efficient refining scheme for these metals from platinum-palladium concentrates and explain each step of the scheme. In order to estimate the conditions, take into account the following facts: average volume of concentrate in a tank is ca. 500 kg, the fraction of all four elements does not exceed 0.5%, and their concentrations can be considered roughly equal. Average value of platinum and palladium (in total) in concentrate can be considered as 95% by weight.

9. **Biology – 21st-century science (MelScience)**

MEL Science produces and distributes educational physics and chemistry sets so users can conduct experiments at home. Propose a prototype of an experiment set for biology and medicine that visually demonstrates a central achievement of molecular biology, biochemistry, or physiology. The proposed set must be completely safe and comply with international shipping regulations.

10. **Atlas shrugged**

Nowadays almost everyone has experienced muscle cramp at least once in their life. Long- term tension of the shoulder girdle and collar zone may lead to cramps of neck muscles. Muscle cramps block blood circulation that results in stagnant and degenerative processes, as well as chronic illnesses. The list of instrumental methods for diagnosing this condition is short and consists of very expensive investigations. Propose a concept for a device capable of diagnosing muscle cramps at home in a timely manner.



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11. The ultimate frontier

The Invincible moved across the outermost quadrant of the Lyre Constellation. The heavy cruiser was propelled through space by photon drive. It was the largest ship at the disposal of the space fleet based in this section of the universe.
Stanislaw Lem "The Invincible"

Annihilation reaction is the most efficient way of getting energy per unit mass of fuel. Let's suppose that we have managed to learn how to obtain and store antimatter in big quantities. Choose and calculate such pair of particles and antiparticles for the annihilation engine to work in such way that it reaches sublight speed as fast as possible. What mass of fuel would be required per each kg of space ship for acceleration? The energy required for confining antimatter can be neglected.

12. Hydrogen water (Werteks)

Recently many nontrivial products have entered pharmaceuticals and nutraceuticals market, though their possible effects on health often remain unproven. One of such products conquering markets, stalls, tables, and water coolers is so-called "hydrogen water", i.e. water saturated with gaseous hydrogen. Evaluate scientific validity of this product from physical, chemical, and biological point of view, and the level of evidential basis of pre-clinical and clinical studies that had been carried out. Based on your conclusions, come up with a consumer-friendly presentation on whether buying hydrogenated water is worth it.

Please, be careful to work through every problem. The problems are divided into 2 units. The day, which each of the unit will be played at, will be announced not later than 3 days before the Grand final. Remember that you may refuse to solve any one problem in each unit. No extended solution (*.doc) is needed.

If you have any questions in regard to the presented information, please do not hesitate to contact Teams' coordinator Miss Polina Lavrik via e-mail: participants@scitourn.com.