International
Chemistry
Tournament

Problems set
of the International Chemistry Tournament 2018
Part 1

This Problem set contains 6 of 12 IChTo-2018 problems.

Problem 1. Redox memory

Propose a redox chemical memory device of at least one kilobyte of memory. A storage of information should be based on reduction-oxidation reactions where an oxidized form of the memory cell components equals “one” and the reduced form equals “zero”. Explain the mechanism of writing and reading for your module. How fast are these processes? What is the size of your device? How long could it store the information without a risk of losing it?

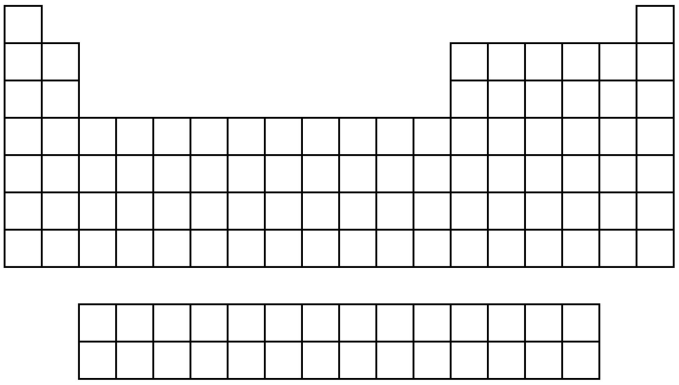
Problem 2. Fluorescent traffic light

Fluorescent dyes emit light of a strictly defined wavelength, which depends on the molecular and electronic structure of the dye molecules. Propose a multicomponent system, that will gradually change the color of its glow after excitation. The system should qualitatively change the character of the glow at least twice between three different colors.

Problem 3. Arodnap and flying islands

On the planet Arodnap, the average atmospheric temperature is about 60 K and it doesn’t fluctuate much during day and night. Unfortunately there is no life, but you may find there some levitating islands, like the ones from the Avatar movie. Of course, the planet Arodnap is fictional. However, try to come up with a plausible mechanism of the formation of such islands. Which processes could lead to the formation of specific minerals, that are in charge of these effects? Suggest, based on this mechanism, the features of Arodnap: its geological history, a composition of the atmosphere and crust and so on.

Problem 4. Periodic table of organic groups

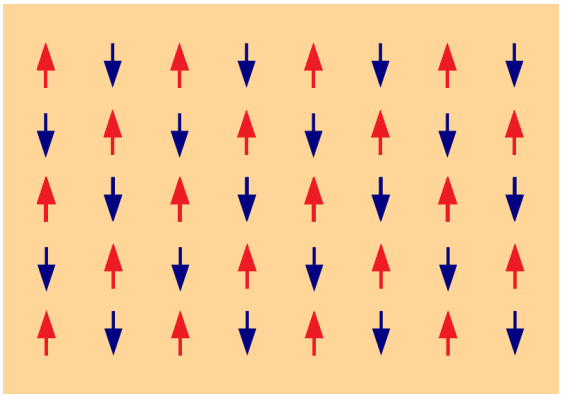


If someone needs to prove the predictive power of science, Mendeleev's periodic table is an obvious choice: it paved the way of chemistry from alchemy to hard science, and correctly predicted features of the Universe which had been completely unheard of (i. e. gallium and germanium).

It is not only that new periodic rules are established day by day. The periodic table of chemistry also inspired the standard model of physics, which is the "periodic table" of elementary particles (electrons, quarks and bosons). But can this idea be extended in other directions?

Construct a periodic table of organic groups. The table should feature the well-known functional groups, but you might consider including some exotic ones, too. The main criterion is that the position of each group should be unambiguous, and you must be able to show the rule of periodicity (how the members of the same column resemble one another). Any predictions you can make are highly appreciated. The format is up to you.

Problem 5. Antiferromagnetic crystal



There are two simplest types of magnetic (spin) ordering in crystals: ferromagnetic and antiferromagnetic. You may think of spins as small magnets. In the first case all spins have the same direction. In the second case, their directions alternate (up / down).

Replace the spins with nanosized magnets (for example, the identical spherical particles of strontium hexaferrite floating in the colloid form). If we try to precipitate these nanoscale magnets using strong external magnetic fields they will form a colloidal crystal and will order as spins in a ferromagnet. Suggest how you can make these nanosized magnets to form an "antiferromagnetic order" in a colloidal crystal.

Problem 6. Superbubble gum

A villain from the “Despicable Me 3” movie uses some kind of superpowered gum to levitate things. For example this gum is capable of lifting cargo ship into the air by forming large lighter-than-air bubbles. Probably this happens after the gum is set in contact with water.

Give a suggestion of the material capable of forming such bubbles after contact with some liquid. Evaluate maximum lifting capacity of your gum. It should at least be able to levitate itself.