doi:10.2533/chimia.2021.894 Chimia 75 (2021) 894

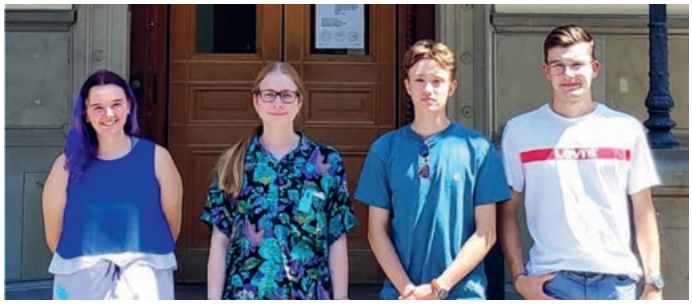
International Chemistry Olympiad 2021

Switzerland at the International Chemistry Olympiad 2021

Maurice Cosandey*

*Correspondence: Dr. M. Cosandey, E-mail: maurice.cosandey@bluewin.ch
Ch. des Etourneaux 1, CH-1162 St-Prex

The 53rd International Chemistry Olympiad (IChO) has taken place online from Japan between July 25th and August 2nd, 2021, with delegations from 85 countries. Each country can send four candidates who must come from the secondary level at school, *i.e.* before university. The Swiss delegation was made of the following delegates:
Antoine Chèvre, 2800 Delémont JU,
CEJEF, Division Technique
Jessica Kurmann, 6295 Mosen LU,
Lehrling Aprentas (Novartis), Muttenz
Anastasia Sandamiraskaya, 8000 Zürich,
Hull's School Zürich
Sandro Pfammatter, 3937 Baltschieder VS,
Kollegium Spiritus Sanctus, Brig



The Swiss team at IChO 2021. From left to right: Jessica Kurmann, Anastasia Sandamiraskaya, Antoine Chèvre, Sandro Pfammatter. Photo Daniel Isler

The examination consisted of nine theoretical problems, with no practical exercises. It was organized online and took place simultaneously in all participating countries. In order to avoid cheating, the candidates had to stay in an isolated room in each country and be filmed during the five hours of the exam. They received the problems at the initial start signal, and had to write down their answers on answer sheets. These sheets were scanned at the end of the exam and sent to the organizers in Japan. These copies were then corrected simultaneously by Japanese organizers and by local mentors, who compared their answers online afterwards. At the end, points were totalized, and the best candidates received gold, silver and bronze medals, always online, of course.

The best result was obtained by a Chinese student, Shu Yang. We have the pleasure to report that the Swiss delegation was awarded with two distinctions. Sandro Pfammatter received a bronze medal, and Jessica Kurmann obtained a honorable mention.

The next International Chemistry Olympiad will take place in 2022 in the Nankai University, Tianjin, China. It should also be noted that the subsequent Olympiad 2023 will be organized in Switzerland at ETHZ. A committee is already at work organizing this event.

The level of difficulty of the tasks to be solved by the candidates at the 2021 IChO can be illustrated by the following Problem 4 :

Problem 4: Chemistry of Zinc

Zinc is a metal that forms each of the three following ions and molecule in aqueous solution: Zn^{2+}, undissociated $Zn(OH)_2$, and $[Zn(OH)_4]^{2-}$. These substances are included in the following equations:

$Zn(OH)_{2(s)} \rightleftharpoons Zn^{2+} + 2\ OH^-$ $\quad K_{sp} = 1.74\ 10^{-17}\ M^3$
$Zn(OH)_{2(s)} + 2\ OH^- \rightleftharpoons [Zn(OH)_4]^{2-}_{(aq)}$ $\quad K_1 = 6.47\ 10^{-2}\ M^{-1}$
$Zn(OH)_{2(s)} \rightleftharpoons Zn(OH)_{2(aq)}$ $\quad K_2 = 2.62 \cdot 10^{-6}\ M$

§1. Calculate the pH range in which the concentration of undissociated $Zn(OH)_2$ is higher than $[Zn^{2+}]$ and $[Zn\{OH)_4]^{2-}$ in solution.
Answer: 8.4 < pH < 11.8

§2. A saturated solution of $Zn(OH)_2$ is prepared at pH = 7. Then NaOH is added so as to obtain pH 12.00. Calculate the molar percentage of zinc that precipitates in this operation as $Zn(OH)_2$.
Answer: 99.5%

§3. When heated at 300 °C, $Zn(OH)_2$ is transformed into ZnO + H_2O. Then ZnO is mixed with H_2, and the following equilibrium occurs;

$ZnO_{(s)} + H_{2(g)} \rightleftharpoons Zn_{(s)} + H_2O_{(g)}$

This reaction is usually displaced to the left-hand side. Calculate the upper limit of the partial pressure of H_2O vapor to allow this reaction to proceed to the right-hand-side at 300 °C and 1 bar. Use the following data: $\Delta G^0\ (ZnO)_s = -290$ kJ/mol, at 300 °C. $\Delta G^0\ (H_2O)_v = -220$ kJ/mol.
Answer: $-4.1 \cdot 10^{-7}$ bar

§4. Zinc is used in air batteries. The electricity is produced by the following equation:

$Zn_{(s)} + ½O_2 \longrightarrow ZnO_{(s)}$ $\quad E° = 1.65$ V

Calculate the change of mass of the zinc electrode, if such a battery has produced 20 mA for 24 hours.
Answer: 0.143 g

§5. At the summit of Mount Fuji (3776 m), the pressure p is 0.420 bar and the temperature in February is -38°C. At the same altitude and temperature, the molar ratio of O_2 is 21%, and the ΔG of the reaction is $\Delta G_{react} = -326$ kJ/mol

Calculate the electromotive force of the Zn-air battery working on top of Mount Fuji in February where the temperature is –38 °C.
Answer: 1.68 V

§6. Calculate the Gibbs energy change at 25 °C for the decomposition reaction of $Zn(OH)_2$ in ZnO and H_2O. You will need the following redox potentials.

$E°(Zn^{2+}/Zn) = -0.77$ V
$E°(O_2/H_2O) = +1.23$ V
Answer: $\Delta G° = 3400$ J/mol

Received: August 22, 2021