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45th International Chemistry Olympiad

Moscow, Russia

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Three Bronze Medals for Switzerland at the 45th International Chemistry Olympiad in Moscow, Russia

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Abstract: A team of four students from Swiss high schools, selected in a national competition and accompanied by their mentors, represented their country at the 45th International Chemistry Olympiad (IChO) held in July 2013 in Moscow, Russia. The exceptional performances of Patrik Willi, Boris Stolz and Mario De Capitani in both practical and theoretical chemistry were rewarded by three bronze medals at the international level, reflecting their efforts during the year-long preparation prior to the competition.

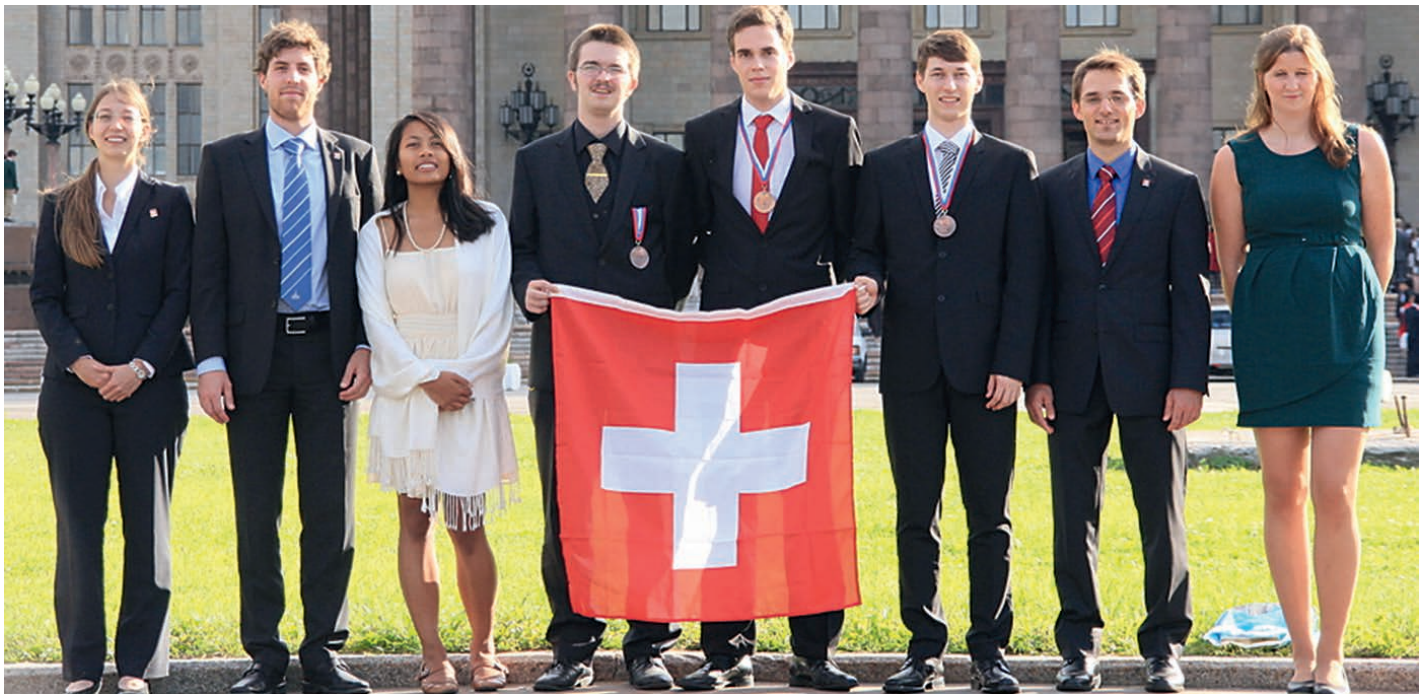
Keywords: Chemistry Competition · Gymnasium · High School · IChO · Russia · Swiss Students · SwissChO

The International Chemistry Olympiad (IChO) is a competition for students at high school level with the aim to promote chemistry to the younger generations and foster bonds across the international scientific community. The first edition was held in Prague, Czechoslovakia, in 1968 and it has been running ever since. Initially exclusively for satellite states of the USSR, it gradually opened to finally encompass representatives from five continents. Switzerland was among the first western nations to be invited to take part in the competition and has attended more than twenty editions. Every year a different nation hosts the event and more and more countries have been participating, culminating this year in a record participation of 77 countries. The competition was held at the Lomonosov Moscow State University, the oldest and among the most prestigious institutions of higher education of Russia. Each country is responsible for the organization of its own national rounds of selection to compose a delegation, which then attends the IChO. This year Switzerland was represented by:

Patrik Willi (Kantonsschule im Lee, Winterthur)
Boris Stolz (Kantonsschule Hohe Promenade, Zurich)
Mario De Capitani (Gymnasium Neufeld, Bern)
Josephine Pratiwi (Gymnase de Morges, Morges)
Who were accompanied by their mentors:
Basile Wicky (head-mentor, ETH Zurich)
Sebastian Keller (mentor, ETH Zurich, Reiher Group)

We are very proud to report the results of our students Patrik Willi, Boris Stolz and Mario De Capitani, who achieved three bronze medals at the international level, a result that had not been equaled by Switzerland since 2004 in Kiel, Germany. In order to achieve such a success, they first had to distinguish themselves in three different rounds at national level and then compete against 290 other students from all over the world in both a theoretical and practical examination of notorious difficulty. The absolute winner of this year was Yuyang Dong from China, achieving an outstanding 85.09% overall. Liechtenstein was officially represented by Lucia Meier (Metrohm AG, ETH Zurich alumni) and Michelle Frei (ETH Zurich) but could not attend with students.

The Olympiad lasted ten days, with mentors and students



The Swiss Team and the Liechtenstein representatives in front of the Lomonosov Moscow State University at the closing ceremony of the 45th IChO. From left to right; Lucia Meier, Basile Wicky, Josephine Pratiwi, Mario De Capitani, Boris Stolz, Patrik Willi, Sebastian Keller and Michelle Frei.

having very different programs and being separated at the beginning to ensure a fair competition. While students take the exams and enjoy a large variety of social and cultural activities, mentors discuss the content of the questions and translate them into their national language(s). They then take part in the marking and arbitration of the results. This year, the Swiss delegation also had the privilege of being invited to a reception held at the residence of His Excellency Mr. Pierre Helg, Ambassador of Switzerland to the Russian Federation, together with Russian scientists, as a testimony of the long-lasting tradition of scientific exchange between the two countries.

Although competition is an important ingredient of such an event, there is much more to it. It is first of all a story of passion, enthusiasm and thirst for discovery that attracts budding chemists from all over Switzerland to take part in the national competition and training camps organized each year by the Swiss Chemistry Olympiad association (SwissChO). The association aims to promote the molecular sciences to high school students and give the opportunity for the motivated ones to learn beyond their curriculum. It is the same motivation that takes them all the way to the IChO, where they get the chance to meet like-minded people; smart young students eager to learn. We would like to congratulate all the participants from both the national Olympiad and the IChO for their curiosity and their achievements. The SwissChO wishes to thank all the members of its organization, the teachers and mentors as well as our generous sponsors, who trained, organized and made the achievement of three bronze medals in Moscow possible.

The next IChO will be held in July 2014 in Hanoi, Vietnam and we already look forward to welcoming students fascinated by chemistry, willing to learn and share our passion.

Example of a Theoretical Question at the 45th IChO

Diverse Permanganatometries

The amount of many reducing agents can be determined by permanganatometric titration in alkaline medium, allowing the reduction of permanganate ion to manganate.

1. Write down the ionic equation for the titration of formate by permanganate in an aqueous solution containing ~0.5 M NaOH.

Titration by permanganate in alkaline medium is often supplemented by addition of a barium salt, which leads to the precipitation of manganate as $BaMnO_4$.

2. Which redox side-process involving manganate is suppressed by the addition of barium salt? Write down an example of equation for the corresponding reaction.

10.00 mL (V_{Mn}) of a 0.0400 M (c_{Mn}) $KMnO_4$ solution were placed in each of the flasks labelled A, B, and C and different reactions were conducted in each one.

3. To flask A, a solution containing an unknown amount of crotonic acid (CA) CH_3–CH=CH–COOH (m_{CA}), base and barium nitrate (both in an excess) was added and the reaction mixture was incubated for 45 min. It is known that each molecule of crotonic acid loses 10 electrons under such conditions. The molar mass of CA is 86.09 g/mol.

a) Write down the total ionic equation of the reaction.

8.00 mL (V_{CN}) of a 0.0100 M (c_{CN}) potassium cyanide solution was further added to the incubated mixture. This resulted in the completion of the following reaction:

$$2Ba^{2+} + 2MnO_4^- + CN^- + 2OH^- \rightarrow 2BaMnO_4 + CNO^- + H_2O$$

The $BaMnO_4$ precipitate was then removed by filtration and the excess cyanide present in the filtrate titrated with a solution of $AgNO_3$ 0.0050 M (c_{Ag}) until detectable precipitation could be observed. Note that both CN^- and CNO^- are analogs of halide ions, but CNO^- affords soluble silver salt.

b) Give the formula of the complex formed when Ag^+ ions were initially added to the cyanide solution (before formation of the precipitate).

c) Give the formula of the precipitate.

d) Calculate the mass of crotonic acid (in mg) if 5.40 mL (V_{Ag}) of the silver salt solution was consumed to reach the endpoint.

4. Another sample with a different concentration of crotonic acid and base (in excess) was added to flask B, this mixture lacking barium salt. An excess of KI (instead of cyanide) was added as a reducing agent. The mixture was then acidified, and the iodine evolved was titrated with 0.1000 M (c_S) thiosulfate solution. 4.90 mL (V_{S1}) of the titrant were used to reach the endpoint.

Calculate the mass of crotonic acid (in mg).

5. A sample containing tin(II) was added to flask C, and the medium was adjusted to weak alkalinity. Tin(II) was quantitatively oxidized to $Sn(OH)_6^{2-}$, whereas a precipitate formed as a result of the reduction of permanganate. The precipitate was isolated, washed, dried at 250 °C, weighed (the mass of the water-free precipitate (m_{prec}), representing a binary compound Mn_xO_y, was 28.6 mg) and dissolved in H_2SO_4 in the presence of an excess of potassium iodide. The evolved iodine was titrated with 0.1000 M thiosulfate solution. 2.50 mL (V_{S2}) of the latter was consumed to attain the endpoint.

a) Determine *x* and *y*. Write down the reaction of precipitation.

b) Calculate the mass of tin in the sample (in mg).

More questions can be found at *www.icho2013.chem.msu.ru*

Answers

1. $2MnO_4^- + HCOO^- + 3OH^- \rightarrow 2MnO_4^{2-} + CO_3^{2-} + 2H_2O$
2. $3MnO_4^{2-} + 2H_2O \rightarrow MnO_2 + 2MnO_4^- + 4OH^-$
3. a) $C_4H_5O_2^- + 10MnO_4^- + 14OH^- + 12Ba^{2+} \rightarrow 10BaMnO_4 + CH_3COO^- + 2BaCO_3 + 8H_2O$
   b) $[Ag(CN)_2]^-$
   c) AgCN or $Ag[Ag(CN)_2]$
   d) 3.00 mg
4. 13.00 mg
5. a) $6MnO_4^- + 13Sn(OH)_4^{2-} + 16H_2O \rightarrow 2Mn_3O_4\downarrow + 13Sn(OH)_6^{2-} + 6OH^-$
   b) 96.4 mg

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