

Conference Report

International Chemistry Olympiad 2024

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Abstract: At the International Chemistry Olympiad 2024 in Riyadh, Saudi Arabia, four outstanding students from Switzerland were awarded with one bronze medal and three honourable mentions. This report highlights the preparation of the Swiss delegation and some excerpts from the international competition. The International Chemistry Olympiad 2025 will take place in the United Arab Emirates. The registration for the corresponding national selection process closes at the end of September.

Keywords: Extracurricular education · International Chemistry Olympiad · IChO · Swiss students

The International Chemistry Olympiad (IChO) is an annual academic competition for high school students. Hosted by a different country each year, four students from each participating country are invited to demonstrate their chemistry knowledge and skills in a 5-hour theory and 5-hour practical exam. A country's delegation is completed by a few mentors and observers in charge of preparing their students, translating the exams into the respective national languages, and ensuring a fair assessment during the competition.

The 56th International Chemistry Olympiad 2024 took place from July 21st to July 30th in Riyadh, Saudi Arabia. It marked the very first IChO hosted in the Arab world. 327 students from 84 countries participated. Moreover, 4 new countries were observing the event to start sending students from next year on.^[1]

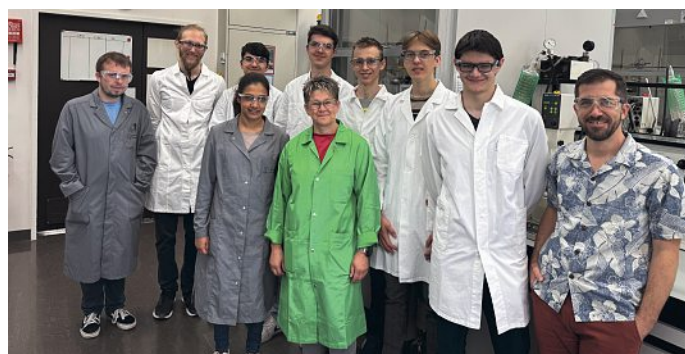
The four spots on the Swiss delegation were awarded at this year's final of the Swiss Chemistry Olympiad (SwissChO), which took place at ETH Zürich in the week after Easter. In a 3-hour theory exam covering all fields of chemistry and a 3-hour practical exam on the very same day, the following four students made the national selection. In the same competition but ranked separately, one student secured his spot at IChO 2024 as a representative of the principality of Liechtenstein:

- Andrin Hauenstein, Kantonsschule Uster (ZH)
- Carl-Philipp Cachej, MNG Rämibühl (ZH)
- Ruben Locher, Berufsfachschule Oberwallis (VS)
- Stanisław Bektaş, International School of Schaffhausen (SH)
- Giulio Vogt, Liechtensteinisches Gymnasium (FL)

These five talented individuals secured their spots from the biggest pool of competitors in the Swiss national selection so far. This year marked the first time when over 700 students participated in the first selection round of SwissChO. We are especially pleased to see this increase after a slight dip in participation numbers last year with IChO 2023 being held in Zürich.^[2–4]

With the learnings our association gathered from being one of the co-organizers of last year's IChO, we aimed to further optimize our preparation of the Swiss delegation. During several preparatory weekends, the students were taught the theory on topics beyond the scope of a typical Swiss high school curriculum. Ad-

ditionally, we organized further practical preparation with the help of Prof. Michal Juríček at the University of Zürich (UZH). We express our deepest gratitude to him and his team for making this possible and providing our students with two more days of practical preparation at UZH.



Practical preparatory weekend at the University of Zürich. Photo: Matus Okajcek.

At the end of July, the Swiss delegation embarked on their journey to Saudi Arabia. Apart from the two exams, the students' program included many excursions to experience Saudi Arabian culture and connect with the international community. Highlights were a trip to Diriyah, a visit to the King Abdul Aziz



Swiss delegation at IChO 2024. Back l.t.r.: Patrik Willi, Andrin Hauenstein, Giulio Vogt, Stanisław Bektaş, Ruben Locher, Silas Waldvogel. Front l.t.r.: Carl-Philipp Cachej, Jasmin Frei. Photo: Swiss Chemistry Olympiad.

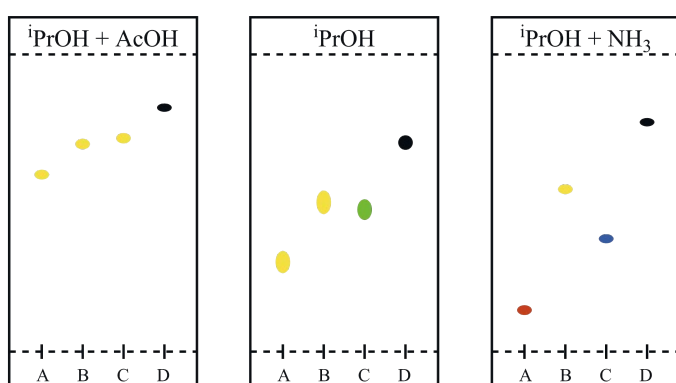
Arabian Horse centre, and a lunch at the Swiss Embassy in Riyadh.^[5]

During the IChO 2024 practical exam, the students faced a chemical riddle with different pH-indicators and had to perform a variety of titrations with the help of a balance. An excerpt from the first problem is presented here.^[6]

Excerpt 1

Acid-base indicators are substances that exhibit different colours in their protonated and deprotonated forms. [...] You will use four indicators [labelled A - D]. One of them has two distinct colour changes at two different pH values.

[At this point, students were tasked to develop TLCs with all indicators on polar silica plates using 1) acidified ⁱPrOH; 2) neat ⁱPrOH; and 3) ⁱPrOH with base. Schematic TLCs are shown below.]



Scheme 1: Schematic representation of developed TLCs for different eluents. Spots for **D** are only visible under UV-light and shown in black.

1.1 Identify the eluent that gives the best spots and best separation of the individual indicators.

In solution, most of these indicators form anions. Only one form of one of the indicators that is observable on the TLC plates is a neutral, molecular species. None of the other three indicators have a neutral form in the eluents used. Some of the indicators with several acidic groups can form dianions as well.

1.2 Based on your observations, **identify** the spots containing the neutral molecular species.

1.3 Based on your observations, **identify** the spot(s) containing dianions of their respective indicator molecule.

In the IChO 2024 theory exam consisting of 9 problems in total, students were, among other things, studying green ammonia production as well as metal complexes extracted from Saudi Arabian petroleum, highlighting a strong commitment of the Kingdom to move its economy from the primary into the quaternary sector. Excerpts from both questions are shown below.^[6]

Excerpt 2

The Haber–Bosch process [...] occurs at constant temperature and pressure, 400 °C and 100 bar, respectively. Equilibrium be-

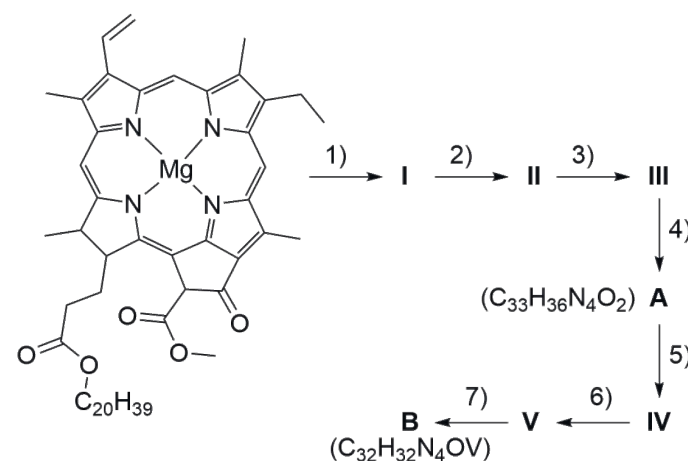
	N ₂ (g)	H ₂ (g)	NH ₃ (g)
Δf H° [kJ mol ⁻¹]	0	0	-45.9
S° [J mol ⁻¹ K ⁻¹]	191.6	130.7	192.8

tween the reactants and the product is established over Fe-based catalysts in the reactor. The standard gas phase thermochemistry data of N₂, H₂, and NH₃ are shown below. Assume the enthalpy and entropy of the reaction are temperature-independent.

2.1 Find the molar conversion (in percent) to ammonia under the production conditions from a stoichiometric mixture of nitrogen and hydrogen.

Excerpt 3

Saudi Arabian petroleum, primarily hydrocarbons, contains elements like vanadium in porphyrin complexes, hinting at its biological origins. Vanadium complex **B** is presumably formed in petroleum from chlorophyll according to the following scheme.



Scheme 2: 1) Demetallation 2) Hydrolysis 3) Decarbomethoxylation 4) Reduction 5) Aromatization 6) Decarboxylation 7) Metal chelation.

3.1 Assign the molecular formulae **a - e** to the intermediates **I - V**.

a	b	c	d	e
C ₃₂ H ₃₄ N ₄	C ₅₅ H ₇₄ N ₄ O ₅	C ₃₃ H ₃₄ N ₄ O ₃	C ₃₃ H ₃₄ N ₄ O ₂	C ₃₅ H ₃₆ N ₄ O ₅

3.2 Draw the structures of intermediate **A** and vanadium complex **B**.

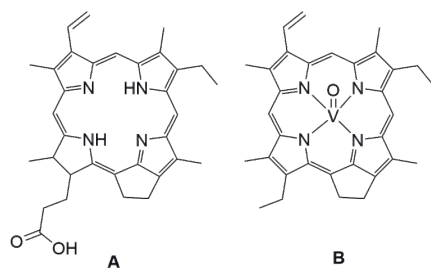
3.3 Indicate the oxidation state of vanadium in **B**.

Readers are invited to attempt to solve the presented excerpts, each solvable within 10 minutes with the solutions provided in the reference list.^[7]

We are excited to report that the Swiss delegation received four awards in Riyadh. Ruben Locher was awarded a bronze medal, while Stanisław Bektaş, Andrin Hauenstein, and Carl-Philipp Cachej each received an honourable mention. This constitutes the best result of a Swiss delegation at an International Chemistry Olympiad since 2015.^[8]

The next edition of IChO will be hosted by the United Arab Emirates in July 2025. The first round of the corresponding Swiss selection consists of a 40 minute online multiple-choice test. Registration closes at the end of September 2024.^[9]

- [1] Press release of SwissChO, <https://chemistry.olympiad.ch/de/news/news/chemie-olympiade-in-saudi-arabien-schweizer-gewinnen-bronze-und-ehrenmeldungen>, accessed Aug. 15th, 2024.
- [2] Official webpage of IChO 2023, <https://www.icho2023.ch/>, accessed Aug. 15th, 2024.
- [3] M. M. de Capitani, *CHIMIA*, **2023**, *77*, 799, <https://doi.org/10.2533/chimia.2023.799>
- [4] D. T. Egger, *CHIMIA*, **2023**, *77*, 800, <https://doi.org/10.2533/chimia.2023.800>
- [5] X (formerly Twitter) Post of the Swiss Embassy, <https://x.com/SwissEmbassyKSA/status/1818577360783839322>, accessed Aug. 14th, 2024.
- [6] The text shown is an adapted and shortened version of the official problem. The original version of the full exams is available at <https://www.icho2024.sa/en/pages/Problems.aspx>, accessed Aug. 14th, 2024.
- [7] Solutions to the presented problems:
1.1 $\text{PrOH} + \text{NH}_3$ with good separation and no tailing. Indicators were provided as methanolic solutions: **A** phenol red, **B** thymol blue, **C** bromocresol green, **D** thymolphthalein.
1.2 Given the eluent composition and TLC plate properties, **D** is present in neutral form in all eluents.
1.3 Deprotonated forms of **A** and **C** based R_f value < 0.5 . Other candidates can be excluded by color and provided information.
2.1 $\Delta H^\circ = -91.8 \text{ kJ mol}^{-1}$, $\Delta S^\circ = -198.1 \text{ J mol}^{-1} \text{ K}^{-1}$, $\Delta G_{400^\circ\text{C}} = +41.6 \text{ kJ mol}^{-1}$, $K_{400^\circ\text{C}} = 5.92 \cdot 10^{-4}$, $K = (2x)^2 (4-2x)^2 (1-x)^{-1} (3-3x)^{-3} (p^\circ/p_{\text{total}})^2$, $x = 51\%$
3.1 a - V, b - I, c - III, d - IV, e - II
3.2



3.3 +4

- [8] Y. Suter, M. Mottet, *CHIMIA*, **2016**, *70*, 125, <https://doi.org/10.2533/chimia.2016.125>
- [9] <https://chemistry.olympiad.ch/en/pupils>, accessed Aug. 14th, 2024.