doi:10.2533/chimia.2006.710 CHIMIA 2006, 60, No. 10

CHEMISTRY OLYMPIAD

Chimia 60 (2006) 710–711

ISSN 0009–4293

A Bronze Medal for Switzerland at the 38th International Chemistry Olympiad 2006 in Korea

Dustin Hofstetter* and Karin Birbaum

Abstract: At the 2006 Chemistry Olympiad in Gyeongsan, South Korea, the Swiss students won a bronze medal.

Keywords: International Chemistry Olympiad · Swiss students

The 38th International Chemistry Olympiad was held in Gyeongsan, South Korea, 2.–11. July 2006. The 254 participants and their mentors came from 67 countries.

The six members of the Swiss team were:
- Yves Aeschi, Lupfig AG
- Frédéric Cottier, Lausanne VD
- Sebastian Keller, Oberwil-Lieli AG
- Lucia Meier, Gipf-Oberfrick AG
- Karin Birbaum (Mentor), Baar ZG
- Dustin Hofstetter (Mentor), Baar ZG

The tasks followed this years' Olympiad motto 'Chemistry for Life, Chemistry for Better Life'. As usual, the participants had to pass a practical and a theoretical exam, each lasting five hours.

Some examples are reported below.

As for the results, Sebastian Keller obtained a bronze medal for his performance. He mastered various tasks from a wide variety of subjects including chemical problems of outer space, solid state, sugars and many more (*vide infra*). The Olympiads were won by Hwan Bae, Korea. Out of competition, Switzerland proved to be more competent in social affairs, when it was voted to be one of the most popular participating countries.

Besides the competition, the students and mentors were shown a broad spectrum of Korean history and culture. Highlights were visits to Hyundai Automotive Factory, the National Museum of Gyeongju, a special martial arts class and various performances of gifted traditional musicians.

The International Chemistry Olympiad is an annual event at changing venues. Future Olympiads will be held in Hungary (2008), Cambridge (2009) and Tokyo (2010). The Swiss Chemistry Olympiads Association looks every year (starting in October) for the most talented students under 20 years. Candidates get the opportunity of training and a great experience of meeting young people from all over Switzerland or even from all over the world.

The next International Chemistry Olympiad will be held in Moscow, Russia from 15. to 24. July, 2007.

The Swiss Team thanks all their supporters. They are specially grateful for the financial support from Ciba, Novartis,

*Correspondence: D. Hofstetter
ETH Zurich
Laboratory for Inorganic Chemistry
Wolfgang-Pauli-Str. 10
CH-8093 Zurich
Tel.: +41 44 633 44 82
E-Mail: dustin.hofstetter@inorg.chem.ethz.ch

CHIMIA **2006**, *60*, No. 10

Roche, Serono, Syngenta, the Metrohm Foundation, the State Secretariat for Education and Research and the Swiss Chemical Society.

The following excerpts of some theoretical Olympic tasks give a taste of the difficulty of the problems to be solved.

Problem 5. Acid-Base Chemistry

5.1. Calculate [H^+], [OH^-], [HSO_4^-], and [SO_4^{2-}] in a 1.0×10^{-7} M solution of sulfuric acid ($K_w = 1.0 \times 10^{-14}$, $K_2 = 1.2 \times 10^{-2}$ at 25 °C). In your work you may use mass- and charge-balance equations. Give the answer to two significant figures.

5.2. Calculate the volume of 0.80 M NaOH solution that should be added to a 250 ml aqueous solution containing 3.48 ml of concentrated phosphoric acid in order to prepare a pH 7.4 buffer. Give the answer to three significant figures. (H_3PO_4 (aq), purity = 85 % wt/wt, density = 1.69 g/ml, FW = 98.00) (pK_1 = 2.15, pK_2 = 7.20, pK_3 = 12.44).

5.3. The efficacy of a drug is dependent on its ability to be absorbed into the blood stream. Assume that the ionic form (A^-) of a weakly acidic drug does not penetrate the membrane, whereas the neutral form (HA) freely crosses the membrane. Also assume that equilibrium is established so that the concentration of HA is the same on both sides. Calculate the ratio of the total concentration ([HA] + [A^-]) of aspirin (acetylsalicylic acid, pK = 3.52) in the blood to that in the stomach.

Problem 7. Hydrogen Economy

7.1. Consider hydrogen in a cylinder of 80 MPa at 25 °C. Using the ideal gas law, estimate the density of hydrogen in the cylinder in kg/m^3.

7.2. Calculate the ratio between heat generated when hydrogen is burned and heat generated when the same weight of carbon is burned. The difference comes to a large extent from the fact that the most abundant isotope of hydrogen has no neutron and hydrogen has no inner electron shell. ΔH_f^o [H_2O(l)] = –286 kJ/mol, ΔH_f^o [CO_2(g)] = –394 kJ/mol.

7.3. Calculate the theoretical maximum work produced by the combustion of 1 kg hydrogen (a) from the electric motor using hydrogen fuel cell and (b) from the heat engine working between 25 °C and 300 °C. The efficiency (work done/heat absorbed) of an ideal heat engine working between T_{cold} and T_{hot} is given by [$1 - T_{cold}/T_{hot}$].

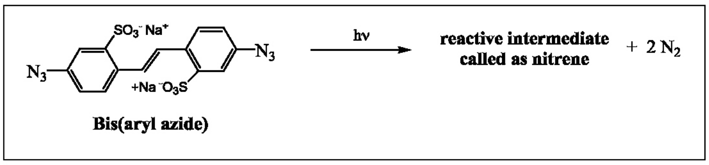

Fig. 1.

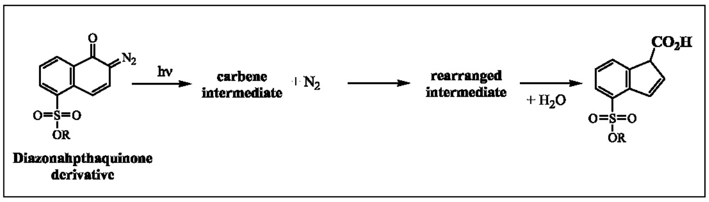

Fig. 3.

$S^o_{298}[H_2(g)]$ = 131 J/(K mol)
S^o_{298} [O_2(g)] = 205 J/(K mol)
S^o_{298} [H_2O(l)] = 70 J/(K mol).

If the fuel cell is working at 1 W and the standard potential difference, how long will the electric motor run at what current?

Problem 8. Chemistry of Iron Oxides

8.1. Development of a technology for reducing iron oxide to iron was a key step in human civilization. Key reactions taking place in the blast furnace are summarized below.

$C(s) + O_2(g) \rightarrow CO_2(g)$
$\Delta H° = -393.51$ kJ(/mol) (1)

$CO_2(g) + C(s) \rightarrow 2CO(g)$
$\Delta H° = 172.46$ kJ(/mol) (2)

$Fe_2O_3(s) + CO(g) \rightarrow Fe(s) + CO_2(g)$
$\Delta H°$ = ? (3)

8.1.1. Indicate the reducing agent in each reaction.

8.1.2. Balance reaction (3) and calculate the equilibrium constant of reaction (3) at 1200 °C. (ΔH_f^o (Fe_2O_3(s)) = –824.2 kJ/mol, S° (J/mol/K): Fe(s) = 27.28, Fe_2O_3(s) = 87.40, C(s) = 5.74, CO(g) = 197.674, CO2(g) = 213.74)

Problem 9. Photolithographic Process

9.1. The earliest photoresists were based on the photochemistry that generates reactive intermediates from bis(aryl azide) (Fig. 1). Patterning becomes possible through the cross-linking reaction of the nitrenes generated from the azides.

9.1.1. Draw two possible Lewis structures of CH_3-N_3, the simplest compound having the same active functional group of bis(aryl azide). Assign formal charges.

9.1.2. Draw the Lewis structure of nitrene expected from CH_3-N_3.

9.1.3. Draw the structures for two possible products, when this nitrene from CH_3-N_3 reacts with ethylene gas (CH_2CH_2).

9.2. Photoresists consisting of Novolak (Fig. 2) polymers, utilize acid to change their solubility. The acid component can be produced photochemically from diazonaphthaquinone. In fact, 'Novolaks' have been the representative 'positive' photoresists of the modern microelectronic revolution.

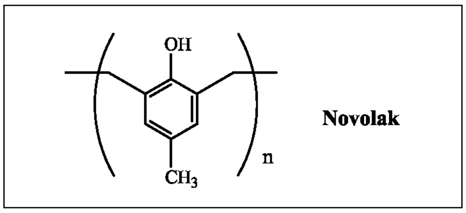

Fig. 2.

When irradiated, diazonaphthaquinone undergoes photochemical decomposition followed by rearrangement to eventually produce a carboxylic acid (Fig. 3).

9.2.1. Draw three Lewis structures of diazoacetaldehyde (Fig. 4), the simplest compound having the same active functional group of diazonaphthaquinone. Indicate formal charges.

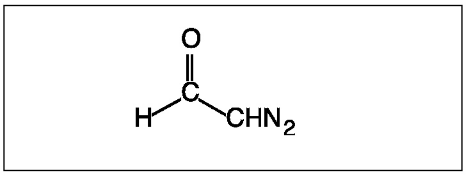

Fig. 4.

9.2.2. Draw a Lewis structure of the rearranged intermediate, A (see below), generated from diazoacetaldehyde after losing N_2. A satisfies Lewis' octet rule and reacts with water to form acetic acid, CH_3CO_2H.

The complete set of questions and their answers in German and French can be found at *http://n.ethz.ch/student/duhofste/icho38*.

Received: August 28, 2006