ICh02021 Catalyzer
No. 4
Jul. 28 2021

Cover illustration : Theoretical Exam

Message from Dr. Akira Yoshino

Hello, everyone. This is Akira Yoshino.

Congratulations to all the representatives from all over the world who participated in the 2021 International Chemistry Olympiad in Japan. I congratulate you on your daily interest in chemistry and the fruits of your enthusiastic learning. We would also like to extend our congratulations and respect to the mentors from each country who have nurtured such wonderful athletes.

The International Chemistry Olympiad is an international event in which high school students from all over the world compete for their chemistry skills. Not only that, but it also builds a human resources network for young people through international exchange and deepens their understanding of Japanese culture. It will be of great significance to develop human resources who will be in a leadership position in the future.

Unfortunately, due to the influence of the new coronavirus pandemic, it has become a remote competition, but even in such a difficult situation, it is the relationship of international trust that has been built up so far. I would like to once again recognize with you that it is supported by the depth of friendship, and I would like to express my sincere gratitude to all the people concerned and the executive committees of each country for their efforts.

Chemistry is central science. It plays an important role in creating new substances by making full use of the properties of elements. I received the Nobel Prize in Chemistry in 2019 for developing a lithium-ion secondary battery and leading it to practical use. In this development, after a long basic research based on the properties of lithium, cobalt, carbon, etc., it was put into practical use. In this way, the results of basic research in chemistry have the power to change the social system. Chemistry must play a leading role in solving various problems such as environment, resources, energy, and health that are currently facing on a global scale. And they are entrusted to a younger generation like you.

You are the leaders of each country and the world in the future. Please take pride in participating in the International Chemistry Olympiad, and remind yourself of the importance of these roles in chemistry for further development.

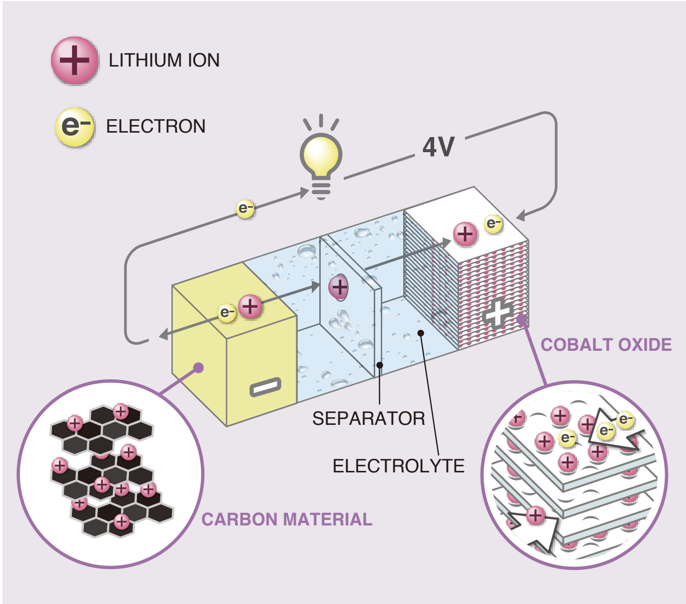
Please do your best in the written test and enjoy the VR videos of various research facilities and cultural activities that are prepared to deepen your exchange.
This is my greeting.

Dr. Akira Yoshino
Honorary Fellow, Asahi Kasei Corp.
2019 Nobel Laureate in Chemistry

Nobel Prize Research from Japan 04

Development of Lithium-ion Secondary Batteries ····· Akira Yoshino

Lithium-ion batteries (Li-ion batteries) are used in all aspects of modern life, from small smartphones and notebook computers to electric vehicles, due to their features such as light weight, rechargeability, and high capacity. It would not be an exaggeration to say that Li-ion batteries enable us to freely carry electricity around. It all started in 1976 when Stanley Whittingham developed a revolutionary rechargeable battery using metallic lithium for the anode and titanium disulfide for the cathode, which intercalates lithium ions. Later, John B. Goodenough developed a battery using lithium-cobalt oxide ($LiCoO_2$) as the cathode, but the practicality of this battery was challenged by the fact that it used metallic lithium as the anode, which posed the risk of explosion and ignition. Akira Yoshino(photo: previous page) overcame these safety and stability issues by using carbon materials for the anode, and laid the foundation for practical Li-ion batteries. For these achievements, Akira Yoshino, John Goodenough, and Stanley Whittingham were awarded the Nobel Prize in Chemistry in 2019. Akira Yoshino was born and raised in Osaka, where IChO2021 was to be held. He says he was inspired to pursue chemistry by the book "THE CHEMICAL HISTORY OF A CANDLE", written by Michael Faraday, which his homeroom teacher in elementary school recommended he read.

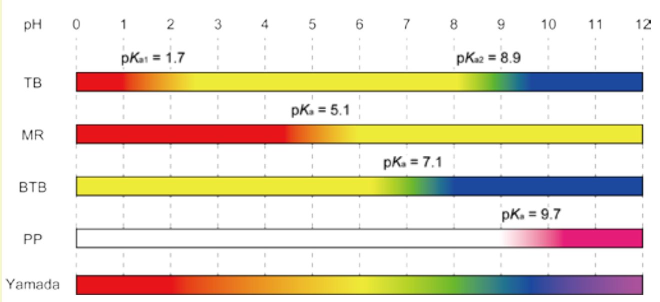


Tale related to Preparatory Problem

Theoretical Task 10

How to make rainbow indicator

Universal indicators are widely used to check the pH values of aqueous solutions. Nowadays, the most popular universal indicator shows red in acidic conditions and blue in basic conditions, the same color variation as that of the rainbow and therefore easy to remember. Is there a suitable molecule that will show such a drastic color change alone? The answer is no: universal indicator is a mixture of several indicators. The original recipe was proposed by a Japanese researcher, Shinobu Yamada, in 1933. Let's see how he cleverly mixed the individual indicators to achieve a rainbow of colors. Thymol blue (TB) changes from red to blue via yellow. To generate the color orange, methyl red (MR) is added. Because of the pKa gap between TB and MR, we can generate an orange color, which is the mixture of red (MR) and yellow (TB), around a pH of 3 to 4. Bromothymol blue (BTB) is used to generate a green color. Using the pKa gap between TB and BTB, we can generate green, which is a mixture of yellow (BTB) and blue (TB), around a pH of 7 to 8. Note that MR in basic conditions and BTB in acidic conditions are yellow. Therefore, too much MR makes the solution green in basic conditions, and too much BTB makes the solution orange in acidic conditions. Fortunately, phenolphthalein (PP) is colorless in acidic and neutral conditions, and therefore the purple color in basic conditions can be adjusted relatively easily. The appropriate constituent ratio is determined by human eyes with a trial-and-error process. We are thankful for Yamada's keen eyes that gave us this universal indicator today.



Color chart of indicators used for Yamada universal indicator (note that the colors and their variations are qualitative).

Chemistry! It's Japan!

Spectrochemical Series ••• Ryutaro Tsuchida

Gems and pigments have attracted human beings with their beautiful colors since ancient times. Such colors are mainly caused by transition metal ions: the colors depend on not only types of metal, but also the ligands attached to the metal, and the coordination structures. However, the colors we see are mere sensory expression, which differs from individual to individual. Thus, quantifying the colors derived from inorganic compounds as energy and understanding the causes of these colors has been a major challenge for complex chemistry.

Complex chemistry was first brought to Japan by Yuji Shibata (1882–1980), who learned from Alfred Werner, the founding father of modern complex chemistry, and later taught at Tokyo Imperial University and Nagoya Imperial University as a Professor. His student Ryutaro Tsuchida, who later taught as professor at Osaka Imperial University, became interested in the relationship between color and ligands in metal complexes. After conducting measurement of the electronic absorption spectra of a numerous kind of metal complexes, he discovered a quantitative relationship between the wavelength of the absorption band and the ligand. Based on this finding, he proposed the spectrochemical series (1938), in which ligands and metal ions are arranged in the order of the energy difference of the d-d transition of octahedral metal complexes. Later, it was theoretically supported by ligand field theory, which considers the covalent nature of the metal–ligand bond, and it became clear that the spectrochemical series is an order of ligand field splitting energies. In addition to colors, Tsuchida was also strongly interested in the steric structure. He assumed the coordination bonds in complexes to be in the same bonding state as the covalent bonds in organic compounds, and the most stable molecular structure is the one that minimizes the repulsion between all electron pairs. This model that Tsuchida conceived was actually almost the same as the model known as the VSEPR rule today; however, this would not be known globally, since Japan was at midst of war. This achievement is very typical of Tsuchida, we may say, who was always conscious of correlations between "structure and properties" of complexes.

Dr. Ryutaro Tsuchida
(1903–1962)

In addition to his chemical research, Tsuchida also devoted himself to the expansion of chemical education as well as his own research. He was involved in producing teaching guidelines for high school chemistry and handbooks to chemical experiments, and he was also involved in launching and publishing chemical magazines for general public. In particular, he was a long-time member of the editorial board of the monthly magazine "*Kagaku* (Chemistry)" (first published in 1951) : this periodical is still published today, and the logo he designed for the magazine is still used as company logo of Kagaku-Dojin.

Complexes synthesized and organized by Tsuchida in the order of the spectrochemical series. Source: *Kinzoku Sakutaino Iro To Kozo* (*The color and structure of metal complexes*), 1944, Zoshinsha.

Company logo of Kagaku-Dojin.

Kansai Scenes 4

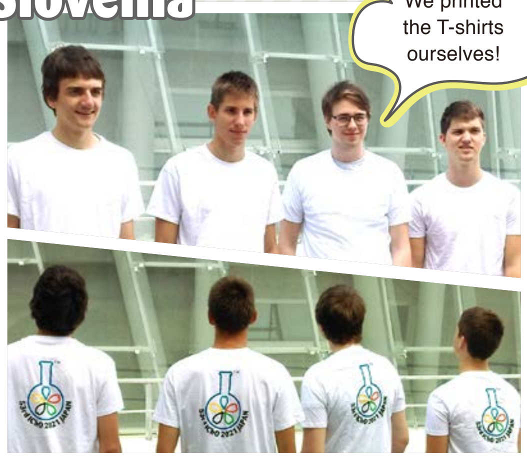
Fushimi Inari Taisha Shrine

Fushimi Inari Taisha, also known as *Oinari-san*, is the most important of the *Inari* shrines that are dotted throughout Japan, and is located in Fushimi-ku, Kyoto. Since the shrine was established in 711, it has been worshipped as a god of good harvest, prosperous business, safety in the home, and fulfillment of wishes. The foxes that serve as messengers of the shrine are also cherished by the people. From the first *torii* gate on the main approach to the shrine, the outer hall of worship (*maiden*), inner hall of worship, and main hall of worship are arranged in a straight line. It is said that there are about 10,000 *torii* contributed by followers, including the beautiful vermilion *senbon torii* (one thousand gates) that line the mountain. *Fushimi Inari Taisha* is one of the most popular tourist spots among people visiting Japan.

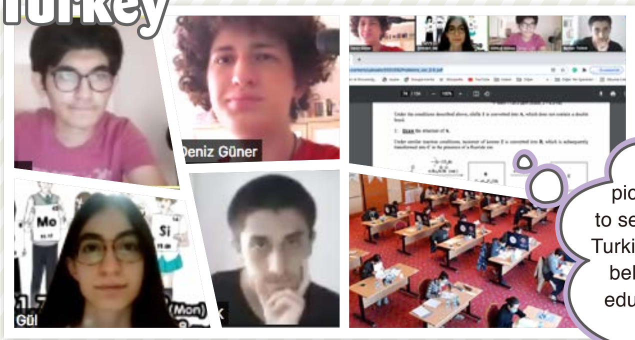
Early Bird Communication

Slovenia

We printed the T-shirts ourselves!

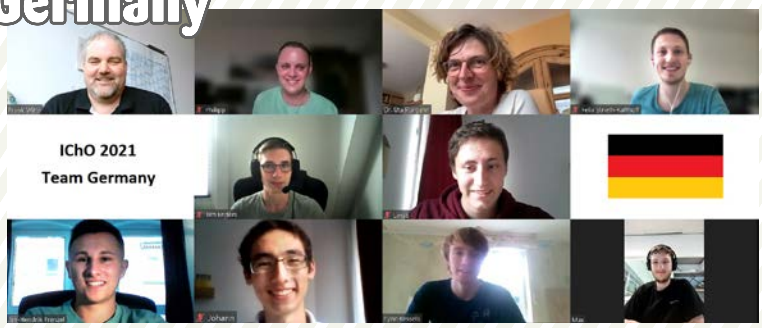


Turkey



One of the pictures belongs to selection exam of Turkish team. Others belong to remote education lessons of team.

Germany



The screenshot is from the conclusion of our virtual study camp on June 11 with selected student representatives for the USA as well as mentors.

Azerbaijan

United States of America

Pakistan

Pics of Team Members for Catalyzer.

Bangladesh

Wish great success of 53rd IChO.

Today's schedule Jul. 28

Student

- **Examination** (5 h) Start between J 14:00 ▸ 05:00 (Jul. 27) C 07:00 ▸ 22:00 E 01:00 ▸ 16:00

Mentor

- **Deadline of translation** J 09:00 C 02:00 E 20:00 (Jul. 27)

Invigilator

- **Receive and print out the problem** J 11:00 C 04:00 E 22:00 (Jul. 27)
- **Submit the solutions** (Within 2 hours after the end of the examination)

Have a nice day!

J : JST = UTC + 9 C : CET = UTC + 2 (summer time) E : EST = UTC - 4 (summer time)

CHEER UP! Participants!

Hello, dear Olympians! My name is Edith Leal and I represented the mexican delegation in the 45th and 46th IChO and now I'm studying my PhD in Chemistry. Looking back from the future, the best advice I can give to you is to give your personal best. Meeting so many young people, who are very intelligent and who seem better prepared for the tasks than you can be very overwhelming, however, remember that just by being here, you have already won a lot of knowledge, from the fundamentals of Chemistry, beyond your usual high school program, to the very specialized Preparatory Problems, which some of them are so specialized, they can be difficult to encounter, even as an undergraduate Chemist. So, stop worrying about anything else and focus into putting everything you know on the questions in the exam, so that when you finish, you feel satisfied and happy with yourself.

Greetings and my very best wishes!

from **Edith Leal** (Mexico)

IChO 45th in Moscow, Russian Federation
Participant

IChO 46th in Hanoi, Vietnam
Bronze medal

Element #3 Japanese mineral resources Lithium

Basic Information

Origin of the name: Greek word *lithos* (stone)
Discovered by: J. A. Arfvedson (Sweden) [1817].
Global reserves: 21 million tons
Major reserve countries: Chile, Australia, Argentina
Global production: 82,000 tons
Major producers: Australia, Chile, China

Lithium-ion batteries are widely used in smartphones and notebook computers today. The applications of these light-weight and high-performance secondary batteries in electric vehicles have grown, in part due to a shift towards a decarbonized society. Akira Yoshino, a Nobel laureate in chemistry in 2019, developed a new battery using a lithium oxide compound as the cathode and a carbon material as the anode (See page 2 of this issue).

© The Courtyard of our Minerals

Answer for Q3

1 Ba

In 1938, German Chemists Otto Hahn and Fritz Strassmann discovered that when uranium-235 is bombarded with neutrons, radioactive barium, krypton, neutrons, and an enormous amount of energy are released. This discovery led to the development of nuclear energy.

ELEMENT QUIZ Q4

Assume you have the same volume of gold, silver, copper, and mercury, and they are all at the same temperature. Which of these metals is the heaviest among them?

1 Gold 2 Silver 3 Copper 4 Mercury

Chemistry! It's Cool!

53rd IChO 2021 JAPAN

IChO2021 Catalyzer No. 4

Official Website
https://www.icho2021.org/
icho2021

Jul. 28
1919
Succeeded!
Transatlantic by R34 airship

Contact Information

IChO2021 Office
1-5 Kanda-Surugadai, Chiyoda-ku, Tokyo 101-0062, Japan
E-mail: contact@icho2021.org
Edited by the Team Catalyzer IChO2021
English Editor: Maiko Katayama
Illustration: Science Manga Studio