# International Chemistry Olympiads: 40 years of youth science competitions. Their impact on the elitist secondary and higher education

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# OUTLINE

- What is IChO?
- Organization of competition
- Syllabus, problems and results
- Ukrainian Chemistry Olympiads. Preparation of Ukrainian teams
- Influence of olympiads on education and preparation of researchers

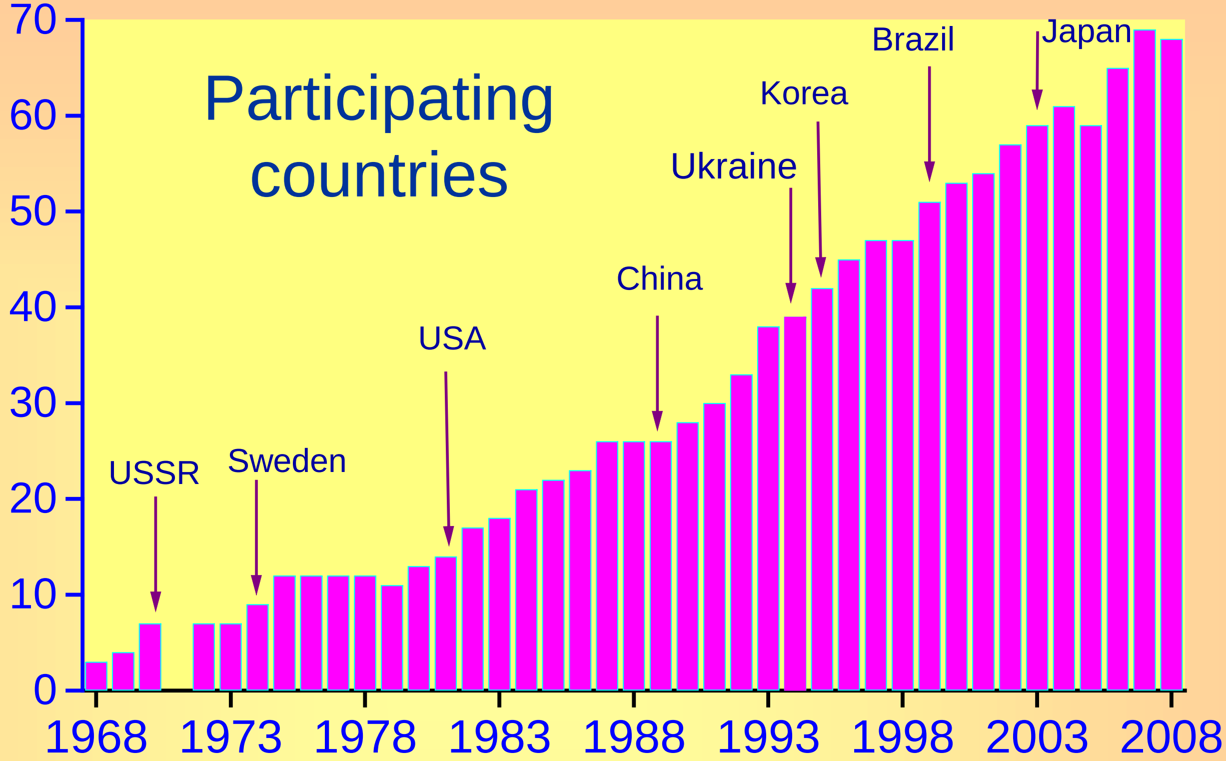

# What is IChO?

“The International Chemistry Olympiad is a chemistry competition for students at secondary school level with the aim of promoting international contacts in chemistry. It is intended to stimulate the activities of students interested in chemistry by a way of independent and creative solving of chemical problems. The IChO competitions help to enhance friendly relations among young people from different countries; they encourage cooperation and international understanding”

*Regulations of the International Chemistry Olympiad, § 1*

# Early beginning:
# 1st olympiads

**1934**: Mathematics (Leningrad and Moscow Universities, correspondence form).
**1938**: Physics (Leningrad University, correspondence form)
**1939**: Chemistry (Leningrad University, correspondence form)
**1963**: Ukrainian chemistry olympiad.
**1966**: Soviet Union chemistry olympiad.
**1968**: International Chemistry Olympiad (Prague, Czechoslovakia), 3 participating countries: Czechoslovakia, Poland, Hungary



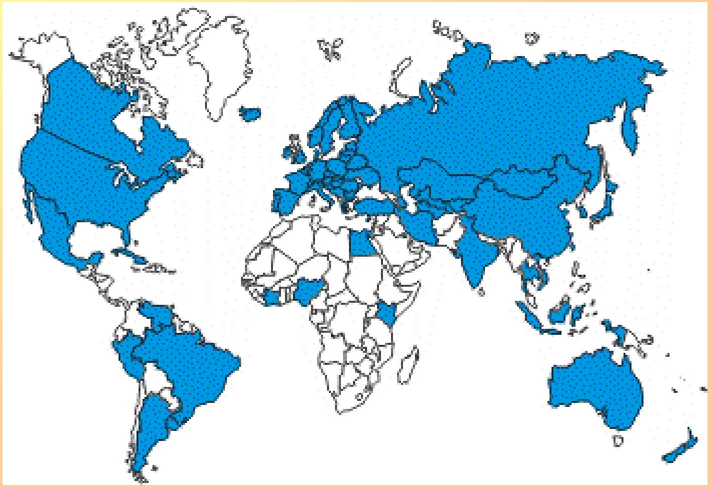

4 students
(younger 20)

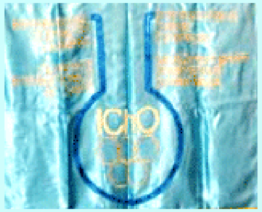
2 mentors

not more than
2 observers

**2008:**

49th Mathematics olympiad, 101 countries
40th Chemistry olympiad, 68 countries
39th Physics olympiad, 82 Countries
19th Biology olympiad, 55 countries
7th Geography olympiad, 23 countries
13th Astronomy olympiad, 42 countries
16th Ecology olympiad, 41 countries
20th Informatics Olympiad



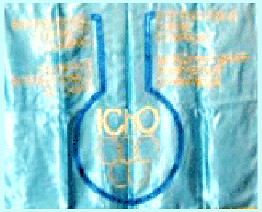


## Organizers

1999 – Thailand, Bangkok
2000 – India, Mumbai
2001 – Denmark, Copenhagen
2002 – the Netherlands, Groningen
2003 – Greece, Athens
2004 – Germany, Kiel
2005 – Taiwan, Taipei
2006 – Korea, budget $ 3 mln
2007 – Russia, Moscow University, budget $ 3 mln
2008 – Hungary, Budapest, budget $ 1.5mln
2009 – UK, Cambridge&Oxford Universities
2010 – Japan, Tokyo, budget up to $ 5 mln
2011 – Turkey, 2012 – USA, 2013 – Singapore
2014 – Vietnam, 2015 - Thailand

## Patrons and sponsors

- UNESCO (at the early beginning), IUPAC, governments, universities, municipalities, national chemistry societies;
- chemical, petrochemical and pharmaceutical industry, charitable organizations.



# Opening ceremony
# Welcome reception
# Inspection of labs



# Discussion of tasks
# Translation


# Practical and theoretical exams
# Social program

# Marking and arbitration. Closing ceremony

Professor Jung-Il Jin, the IUPAC President



Dmytriy Medvedev, President of Russia


# Syllabus and problems

**Regulations:**
The organizer distributes a set of preparatory tasks written in English to all participating countries in the January of the competition year.

**Basic chemical concepts and facts** may be included into the olympiad tasks without any mention in the preparatory problems. The elementary laboratory skills are needed too (for instance, heating under reflux; mass and volume exact measurements; carrying out of test tube reactions; testing for organic functional groups; volumetric titrations: measurement of pH by pH-meter).

**6 theoretical and 2 practical complicated topics may be included into the preparatory problems.**

## Examples of advanced knowledge and skills

- Schrödinger equation, MO theory
- IR, NMR and mass-spectra
- Inorganic stereochemistry, isomerism in complexes
- Solid state structures and Bragg’s law
- Formal kinetics, determination of activation energy, collision theory, steady-state and quasi-equilibrium approximations, mechanisms of catalytic reactions
- Phase diagrams and the Clausius-Clapeyron equation
- Calculation of solution and multiphase equilibria
- Stereoselective transformations (diastereoselective, enantioselective), optical purity
- Conformational analysis, use of Newman projections

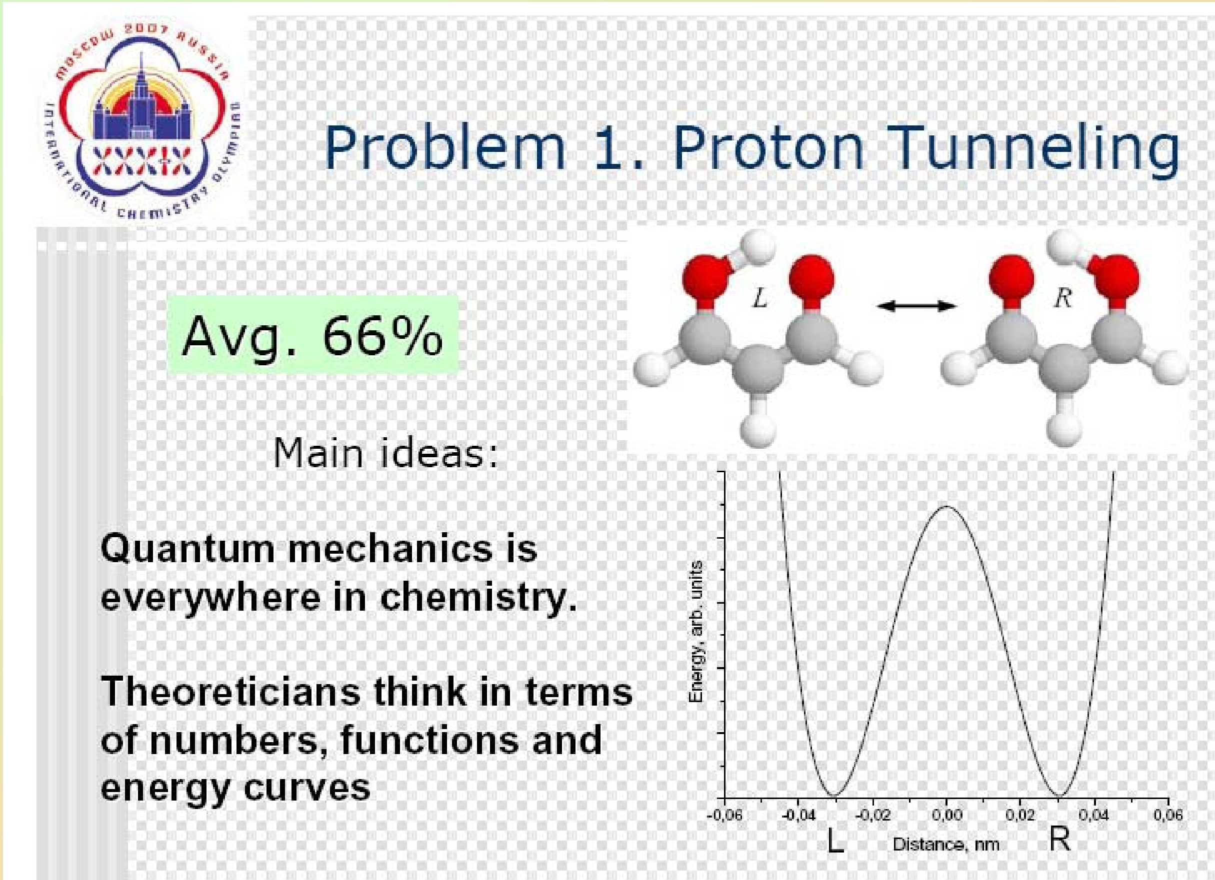
## Examples of advanced knowledge and skills

- Aromatic nucleophilic substitution, electrophilic substitution on polycyclic aromatic compounds and heterocycles
- Supramolecular chemistry
- Advanced polymers, rubbers, copolymers. Kinetics of polymerization
- Enzymes and classification according to reaction types, active sites, coenzymes and cofactors, mechanism of catalysis
- Synthesis in microscale equipment
- Advanced inorganic and organic qualitative analysis
- Spectrophotometry
- Extraction with immiscible solvents
- TL and column chromatography

## Chemistry at the 39th IChO, Moscow, 2007

### Motivations

- **To get pleasure from mental work**
- **To learn something new about chemistry**
- **To suggest creative problems**
- **To introduce modern chemistry to the students**



# Chemistry at the 39$^{th}$ IChO, Moscow, 2007

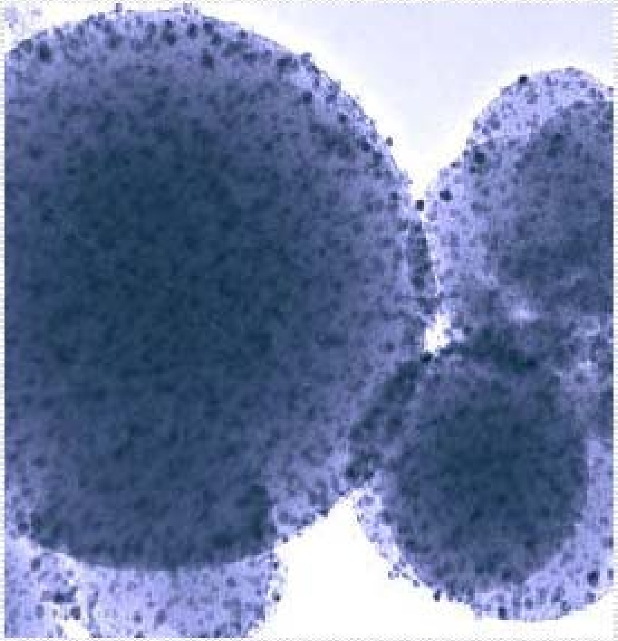
## Problem 2. Nanochemistry

Avg. 40%

Main ideas:

**Thermodynamic functions are size-dependent.**

**Change of the particle size can be in favor of both desirable and undesirable reactions**



# Chemistry at the 39th IChO, Moscow, 2007

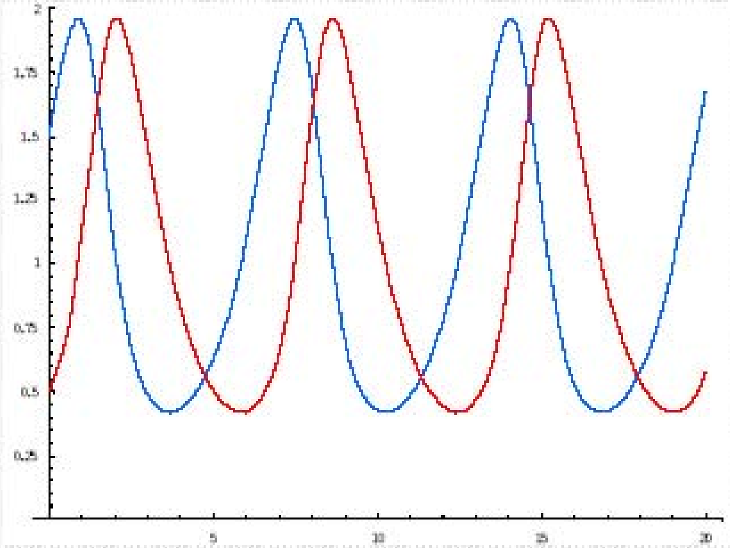
## Problem 3. Unstable Reactions

Avg. 56%

Main ideas:

In an open system autocatalytic steps can lead to an oscillatory behavior

Changing the initial concentrations or the rate constants can result in the different kinetic curves



# Problem 4. Determination of Water by Fischer Titration

Avg. 43%

Main ideas:

**Fischer method was discovered 100 years ago but still is the best method for the determination of water**

**The problems involves complicated stoichiometric calculations which vary from substance to substance**

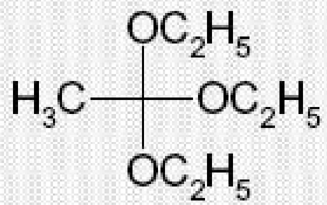
# Chemistry at the 39th IChO, Moscow, 2007

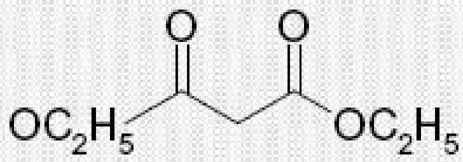
## Problem 5. A Mysterious Mixture (Organic Hide-and-seek Game)

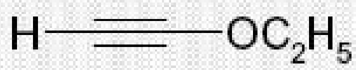
Avg. 31%

Main idea:

**There are some “hidden forms” of acetic acid.**







# Chemistry at the 39th IChO, Moscow, 2007

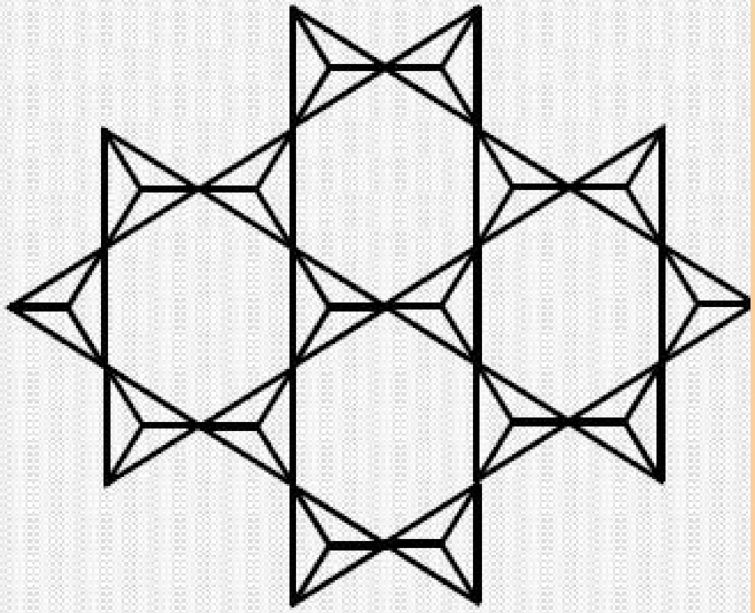
## Problem 6. Silicates as the Base of the Earth Crust

Avg. 50%

Main ideas:

**Chemistry (even of silicon) is not boring at all**

**Chemistry is not only formulas and equations but also nice pictures**



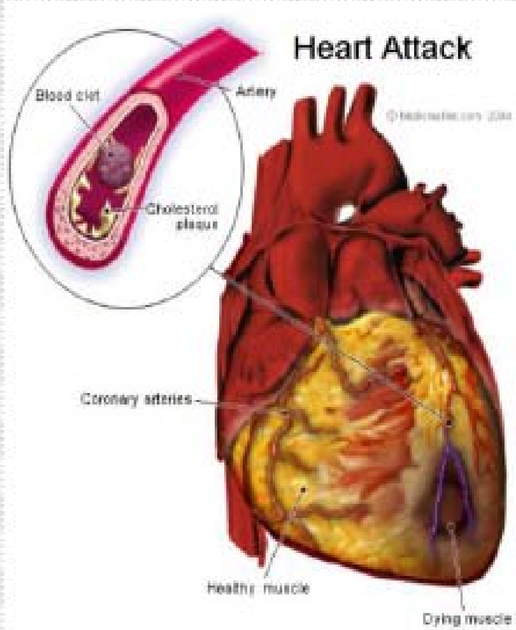
## Chemistry at the 39th IChO, Moscow, 2007

# Problem 7. Atherosclerosis and Intermediates of Cholesterol Biosynthesis

Avg. 25%

Main idea:

**Understanding the cholesterol metabolism is crucial for the treatment and prevention of cardiovascular diseases**



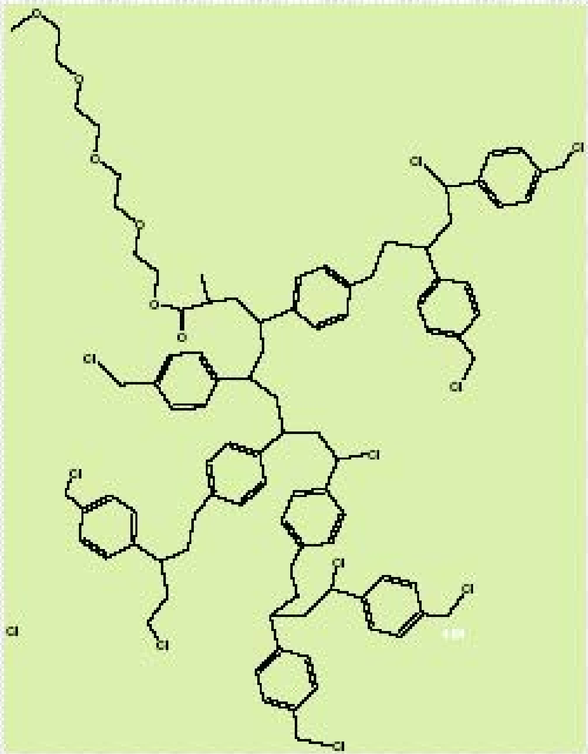
# Chemistry at the 39th IChO, Moscow, 2007

## Problem 8. ATRP Allows New Polymers

Avg. 26%

Main idea:

**Atom transfer radical polymerization (ATRP) is an important novel approach for the controlled radical polymerization**



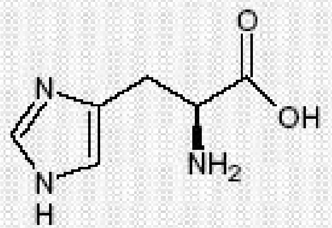
## Chemistry at the 39th IChO, Moscow, 2007

# Experimental Problem 1. Ion-exchange chromatography of amino acids

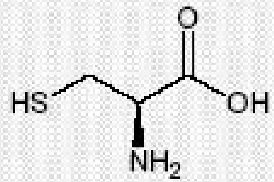
Avg. 31%

Main idea and steps:

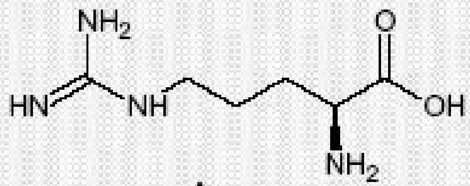
**Separation of a mixture of three amino acids with subsequent qualitative and quantitative analysis**




His




Cys




Arg

# Chemistry at the 39th IChO, Moscow, 2007

## Experimental Problem 2. Determination of carbonate and hydrogen phosphate in an abrasive sample

Avg. 36%

Main idea:

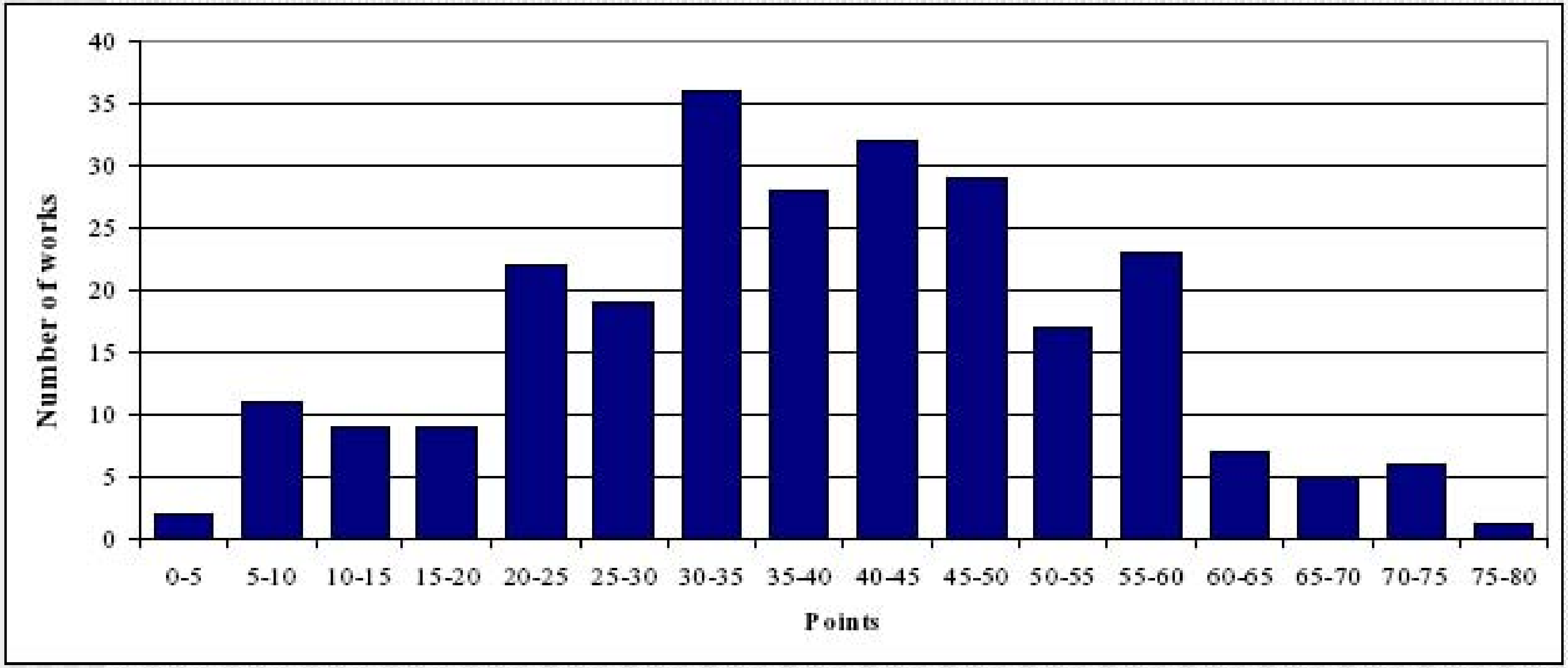
**Determination of two ions in a mixture by acid-base titration. The procedure involves all basic analytical techniques: dissolution, precipitation, filtering, titration, calculations**

$$Ca^{2+} + H_2PO_4^- \rightarrow CaHPO_4 + H^+$$

$$3Ca^{2+} + 2HPO_4^{2-} \rightarrow Ca_3(PO_4)_2 + 2H^+$$

# Chemistry at the 39th IChO, Moscow, 2007

## Distribution of points



## The most difficult practical task at the 40th IChO

You have 8 unknown aqueous solutions. Each solution contains only one compound. The same ion may appear in more than one solution. Every compound formally consists of one type of cation and one type of anion from the following list:

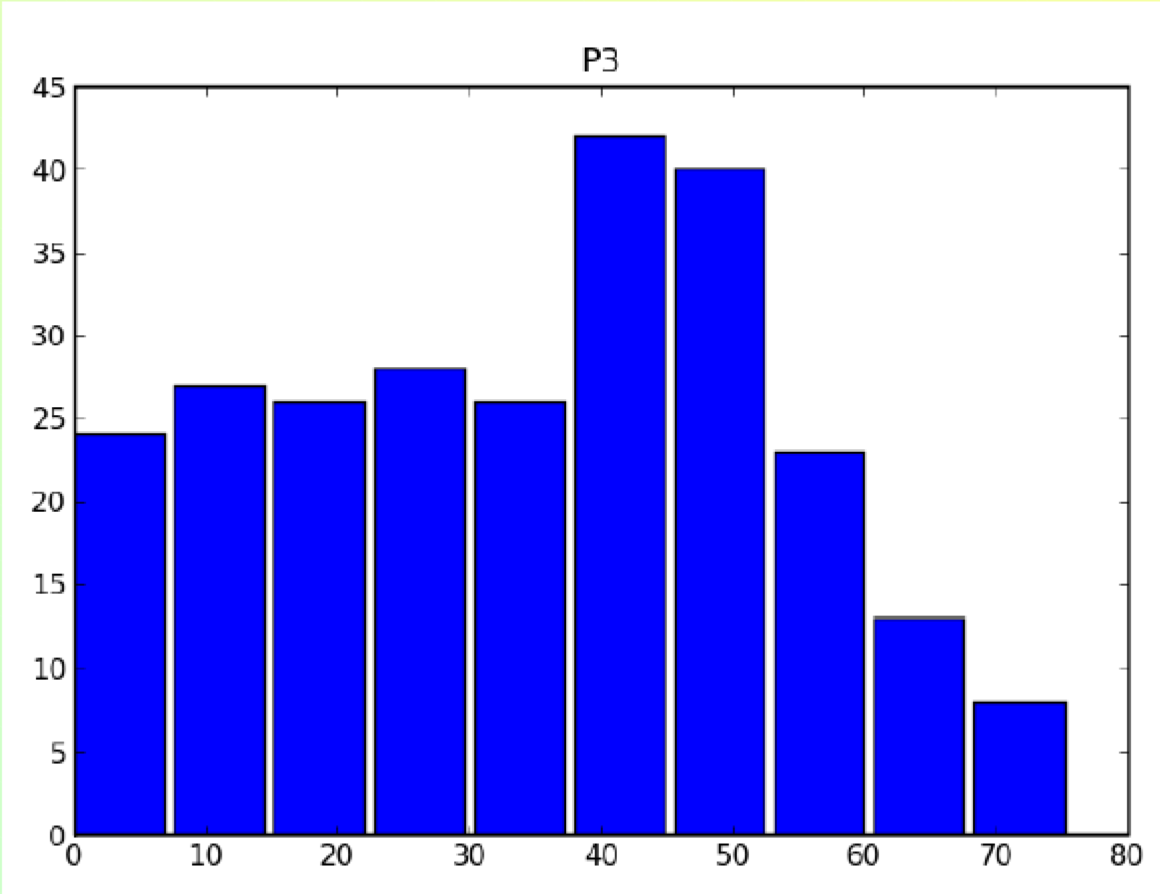
Cations: $H^+$, $NH_4^+$, $Li^+$, $Na^+$, $Mg^{2+}$, $Al^{3+}$, $K^+$, $Ca^{2+}$, $Cr^{3+}$, $Mn^{2+}$, $Fe^{2+}$, $Fe^{3+}$, $Co^{2+}$, $Ni^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Sr^{2+}$, $Ag^+$, $Sn^{2+}$, $Sn^{4+}$, $Sb^{3+}$, $Ba^{2+}$, $Pb^{2+}$, $Bi^{3+}$

Anions: $OH^-$, $CO_3^{2-}$, $HCO_3^-$, $CH_3COO^-$, $C_2O_4^{2-}$, $NO_2^-$, $NO_3^-$, $F^-$, $PO_4^{3-}$, $HPO_4^{2-}$, $H_2PO_4^-$, $SO_4^{2-}$, $HSO_4^-$, $S^{2-}$, $HS^-$, $Cl^-$, $ClO_4^-$, $MnO_4^-$, $Br^-$, $I^-$

You have test tubes and heating but no additional reagents apart from distilled water and pH paper.
Identify the compounds in the solutions **1**-**8**. If you are unable to identify an ion exactly, give the narrowest selection possible.

# The most difficult practical task at the 40th IChO
2 hours, maximum 108 pts

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| $AgNO_3$ | $KHCO_3$ | $NH_4ClO_4$ | $NaOH$ | $NaHS$ | $Pb(OAc)_2$ | $BaI_2$ | $MgSO_4$ |



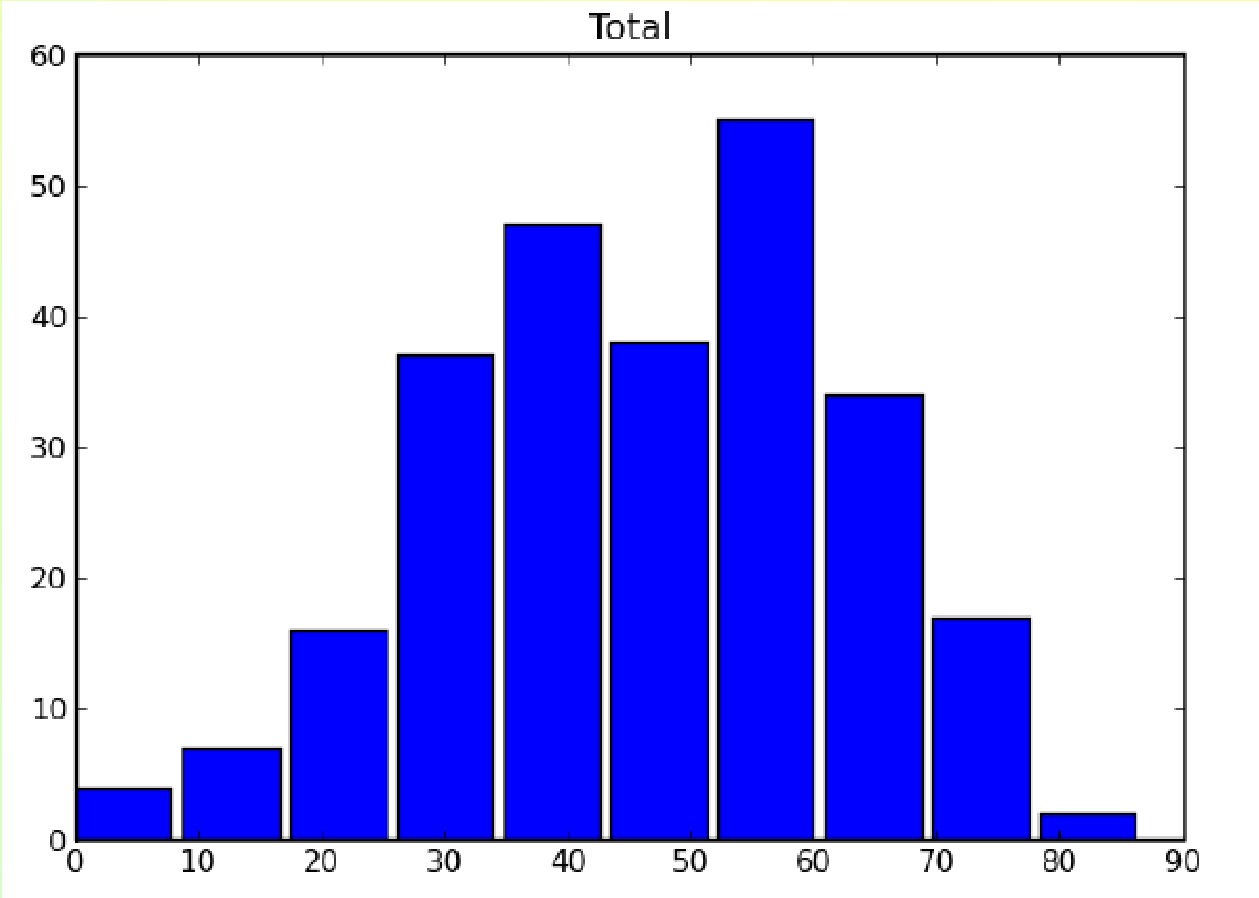
The final results of the 40th IChO
Maximum possible mark: 100

**257 participants**

30 gold medals
Marks: 88-66.7

52 silver medals
Marks: 66.6-56

78 bronze medals
Marks: 66.6-41



# Unofficial command ranks

Year (in 2005 China was absent)

| 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|
| 1. China | 1. China | 1. China | 1. Korea |
| 2. Thailand | 2. Iran | 2. Korea | 2. Vietnam |
| 3. Taiwan | 3. Korea | 3. Russia | 3. Iran |
| 4. Ukraine | 4. Thailand | 4. Ukraine | 4. Russia |
| 5. Korea | 5. Belarus | 5. Germany | 5. Taiwan |
| 6. Austria | 6. Russia | 6. Poland | 6. Thailand |
| 7. USA | 7. India | 7. Taiwan | 7. Argentina |
| 8. Poland | 8. Singapore | 8. Hungary | 8. Germany |
| 9. India | 9. Germany | 9. Turkey | 9. India |
| 10. Germany | 10. Taiwan | 10. Vietnam | 10. Austria |
| 11. Iran | 11. Ukraine | 11. India | 11. Ukraine |
| 12. Hungary | 12. Poland | 12. Iran | 12. Czech |
| 13. Russia | 13. Canada | 13. Romania | 13. Poland |
| 14. Canada | 14. Czech | 14. Lithuania | 14. Australia |
| 15. Turkey | 15. Romania | 15. Czech | 15. Turkey |
| 16. Australia | 16. Kazakh | 16. USA | 16. Hungary |
| 17. UK | 17. Vietnam | 17. Singapore | 17. Slovakia |
| 18. Singapore | 18. Estonia | 18. Canada | 18. USA |
| 19. Spain | 19. UK | 19. Australia | 19. UK |
| 20. Slovakia | 20. Australia | 20. Kazakh | 20. Romania |
| 21. Belarus | 21. Hungary | 21. UK | 21. Belarus |
| 22. Vietnam | 22. Slovakia | 22. Japan | 22. Singapore |
| 23. Finland | 23. USA | 23. Austria | 23. Japan |
| 24. France | 24. Venezuela | 24. Belarus | 24. Indonesia |
| 25. Lithuania | 25. India | 25. Slovakia | 25. Latvia |
| 26. Czech | 26. France | 26. Thailand | 26. Belgium |
| 43. Brazil | 44. Brazil | 45. Brazil | 46. Brazil |

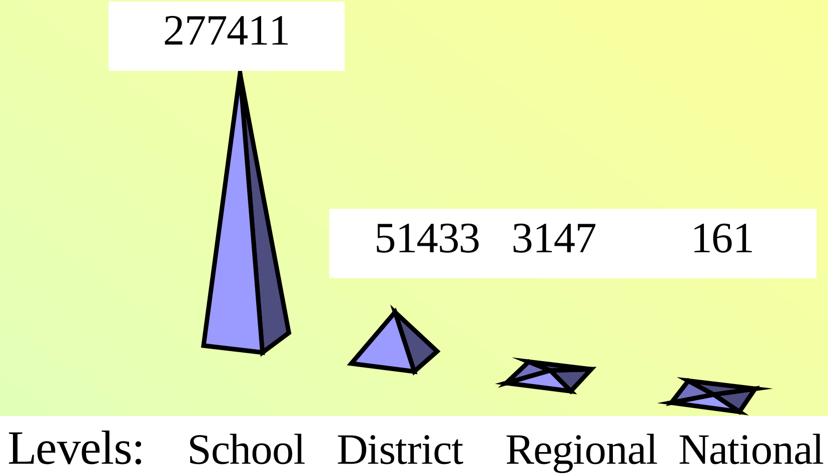
# Unofficial command ranks

| 2006 | 2007 | 2008 |
|---|---|---|
| 1. China | 1. China | 1. China |
| 2. Taiwan | 2. Russia | 2. Russia |
| 3. Korea | 3. Taiwan | 3. Ukraine |
| 4. Russia | 4. Poland | 4. Korea |
| 5. Korea | 5. Korea | 5. Thailand |
| 6. Vietnam | 6. Germany | 6. Belarus |
| 7. Thailand | 7. Thailand | 7. Vietnam |
| 8. Japan | 8. India | 8. Taiwan |
| 9. Poland | 9. Hungary | 9. Hungary |
| 10. India | 10. Slovakia | 10. Singapore |
| 11. Germany | 11. Latvia | 11. Kazakh |
| 12. Slovakia | 12. USA | 12. Austria |
| 13. Denmark | 13. Vietnam | 13. Poland |
| 14. Ukraine | 14. UK | 14. Iran |
| 15. Singapore | 15. Belarus | 15. India |
| 16. Brazil | 16. Estonia | 16. Romania |
| 17. Canada | 17. Ukraine | 17. Australia |
| 18. USA | 18. Argentina | 18. Germany |
| 19. Hungary | 19. Iran | 19. Slovakia |
| 20. Czech | 20. Romania | 20. Turkey |
| 21. Australia | 21. Australia | 21. Lithuania |
| 22. Ireland | 22. Austria | 22. Estonia |
| 23. France | 23. Kazakh | 23. Italy |
| 24. Iran | 24. Singapore | 24. UK |
| 25. Austria | 25. New Zealand | 25. Canada |
| 26. Turkey | 26. Czech | 26. Brazil |
| | 33. Brazil | |


# Ukrainian Chemistry Olympiad

- **end of March**
- **8-11 forms**
- **2 theoretical + experimental tours**

~8%:1st place winners
~17%: 2nd place winners
~25%:3rd place winners




**Participants of the Chemistry Olympiad in academic year 2007/2008**

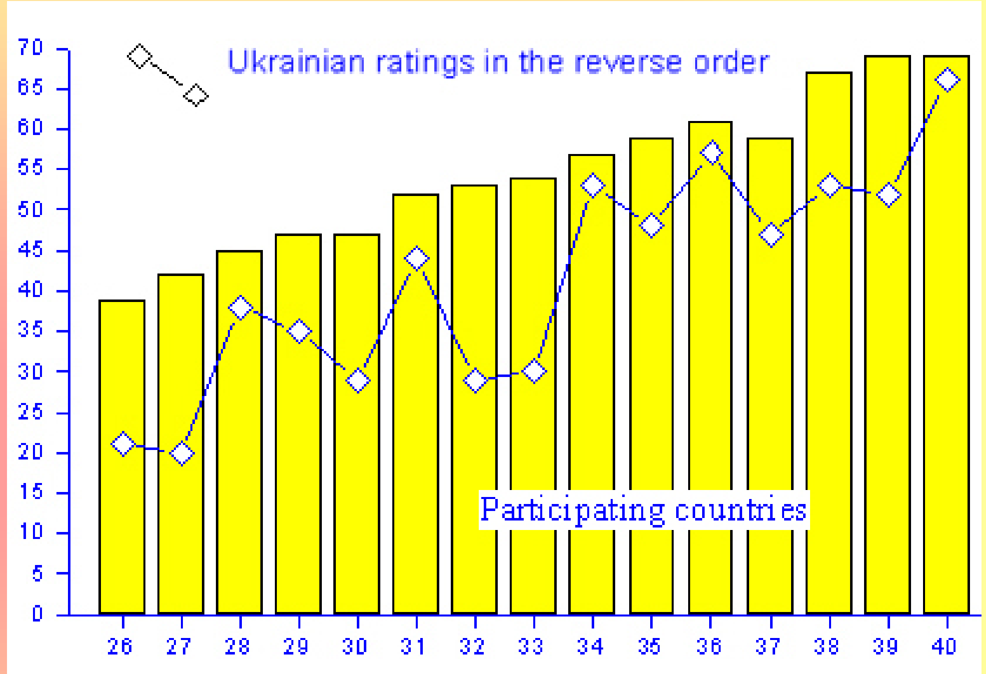
**http://www-chemo.univer.kharkov.ua/olympiad.htm**


# Ukrainian Chemistry Olympiad

**Aims**

- **to compensate (to a certain extent) the collapse of the national education system;**
- **to promote science education in secondary schools;**
- **to demonstrate that chemistry is not boring and to give possibilities for students to reveal their creativity;**
- **to help young people from poor families and depressed regions to show themselves.**


# Ukrainian Chemistry Olympiad




**Training**

- ➢ Syllabus of the Ukrainian olympiad, learning materials, and many tasks are accessible from the web;
- ➢ special textbooks were published;
- ➢level of tasks for the 11th form takes into account the IChO level;

- ➢Russian translation of the preparatory problems is distributed between best 8 students of the 11th form at the Ukrainian olympiad;
- ➢ In May the 10 day training camp in Kharkiv University (lectures, labs, exams);


# Ukrainian Chemistry Olympiad

**Stimulation**

- Entrance in the HEI without exams;
- High scholarships, grants;
- Government awards for school teachers.

**Team:** balanced union of

- experienced university professors,
- young scientists from Academy of Sciences and business structures, and
- undergraduate students.

The majority of members participated in Ukrainian and International chemistry olympiads

# PROGRAMA NACIONAL OLIMPÍADAS DE QUÍMICA

http://www.obq.ufc.br/

REALIZAÇÃO

Associação Brasileira de Química

PROMOÇÃO

Universidade Federal do Ceará

UFPI
Universidade Federal do Piauí

APOIO

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico
50 ANOS

ABEQ

BR
PETRÓLEO BRASILEIRO S.A.
PETROBRAS

Banco do Nordeste

ABIQUIM

abiclor

# Former IChO participants: post-olympiad life

1994: Sergey Kolotilov – PhD, Senior Research Fellow, the Ukrainian Academy of Sciences, Associate Professor at Kiev National University, **Ukraine**

1995: Yaroslav Filinchuk– PhD, Research Fellow, the Swiss-Norwegian Beam Lines at the European Synchrotron Radiation Facility, Grenoble
Maxim Kryuchkov – organic chemist, Canada
Anton Samoteykin – small-scale private businessman, **Ukraine**
Konstantin Pasichnichenko – PhD, Postdoctoral Fellow, the USA

1996: Anton Granzhan – PhD, Postdoctoral Fellow, Institute Curie, Paris

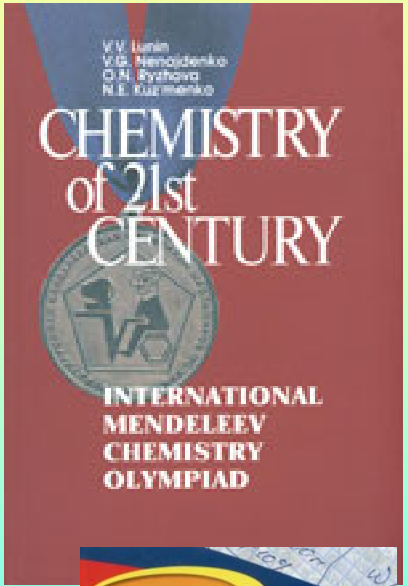

# Former IChO participants: post-olympiad life

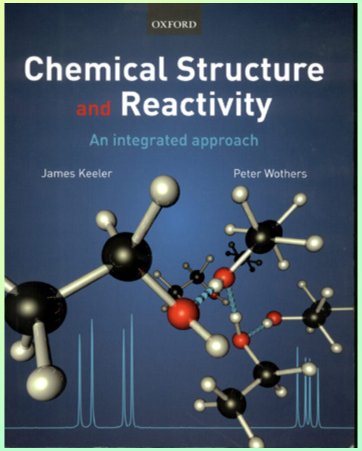
1997: Dmytro Volochnyuk – PhD, Senior Research Fellow, Ukrainian Academy of Sciences, **Ukraine**,
Ratmir Derda - PhD, Postdoctoral Fellow, Department of Chemistry and Chemical Biology, Harvard University

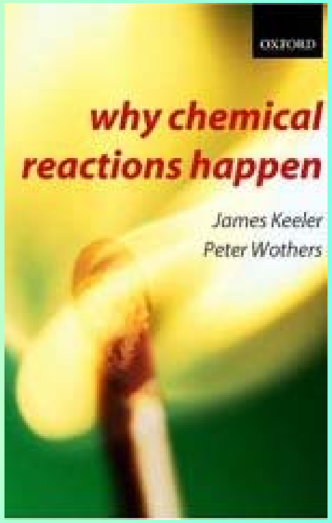
1998: Alexander Predeus – PhD, Department of Chemistry, Michigan State University
Oleg Yazev – PhD, Research Associate, Institute of Theoretical Physics, Lausanne

1999: Olexander Grygorenko – PhD, Research Fellow in Kiev University, **Ukraine**,
Konstantyn Chernychenko – MSc, leading researcher in the innovation company, Moscow,
Maksym Artemov – PhD student, the USA,
Sergiy Bukreev – PhD student, Cambridge

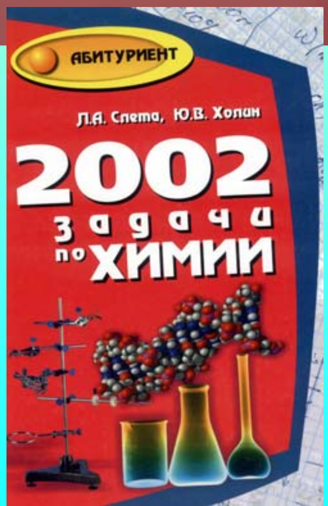
# Some publications

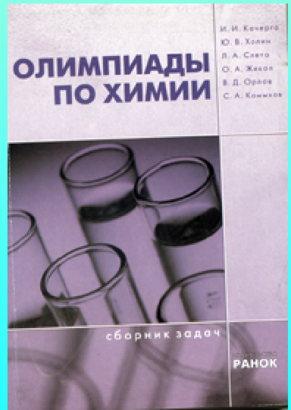


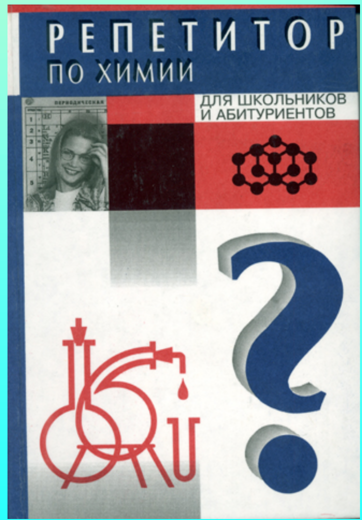








# THANK YOU!