The content and extent of the theoretical part of the IChOs

The content and extent of the theoretical tasks of the IChOs were the subjects of the many discussions of the International Jury in the past. It is not astonishing since they influence the results of competing pupils in a deciding manner. Moreover, the content of the competition tasks has a direct connection with the teaching programs of chemistry at the secondary schools in the particular countries. Naturally, the mentors/teachers compare the possibilities of the teaching programs in their countries with the requirements of the IChO but this can be find positive and may serve as an inspiration factor.

Many useful discussions took place on different levels (the International Jury, the Working Groups, discussions with the authors, etc.) and resulted in many sheets of paper with printed recommendations and conclusions. It is not possible to write about them in all details but all of them are preserved in other materials such as reports from the meetings of working groups, international jury and steering committee, seminars or final reports from the particulars International Chemistry Olympiads.

Correspondingly the volume of the theoretical competition tasks has enlarged. The first organizer did not need a lot of paper, as the complete competition took only two pages. The 10th IChO had 10 pages for the theoretical part, the 20th IChO 13 pages and the 29th IChO showed only 12 pages, but with smaller fonts, more typed lines per page and additional answer sheets. It is taking a lot of time only to read a whole set of theoretical tasks! Therefore it was decided to express the limits of the text of theoretical part via the number of letters used for the task altogether with answer sheets (25 000).

Nearly each organizer wanted to show some specialties. From the beginning of the IChOs students got tasks from application of the gas law). The 2nd IChO brought the organic chemistry and the first stoichiometry, inorganic chemistry and from general and physical chemistry (which was rather simple, e.g. the electrochemical task (an electrolysis). Later, a new field was added to each IChO as it is shown in Table 1. (The following examples are more or less detailed.)

Table 1. New fields added to the theoretical part of IChO during the years 1970 - 1998

IChO (#)	New field in the theoretical tasks
3	equilibrium
4	thermochemistry
5	equilibrium with ions
6	electrochemistry combined with organic chemistry
7	theory of the chemical bonding
8	optical activity
9	photochemistry, coupled equilibria
10	thermodynamics

11	choosing of apparatus for a lab experiment
12	conformation of organic molecules
13	kinetics, sugars
14	solubility product, complex chemistry
15	organic reaction mechanism
16	radioactivity, biochemistry
17	MO-theory
18	technical chemistry, enzymatic reactions
19	potentiometry
20	quantum numbers, mass spectra, X-rays, VSEPR
21	labeled compounds
22	organic chemistry with deuterated compounds
23	de Broglie wave length
24	Pourbaix diagrams
25	chromatography
26	infrared spectra
27	ion selective electrodes
28	bridged systems
29	atmospheric chemistry

Before the 29th IChO, the jury sessions and translations were going on for the whole night (for some teams it is still the case). The total time for discussion and translation remained the same because on the one hand the jury had to discuss more and longer tasks, on the other hand, however, the work became easier.

In 1988 it was for the first time that the delegations got the tasks some hours before a discussion. In 1991 and it was for the first time that the mentors got a chance to speak with the authors of the theoretical tasks before the discussion in the jury took place.

In order to save a lot of time for translation during the night, in 1997 the jury was divided into two groups for the discussion of the theoretical tasks.

It is worthy to mention that in Frankfurt (1984) the jury discussion was held for the first time in one language (English) without interpreting into the other so-called official languages (German, French, Russian). Starting with Pittsburgh 1992 it was not longer necessary to use typewriters together with scissors, adhesives and tippex, as the members of the jury were given personal computers for each language at the disposal. But it seems to be so that instead of shortening the night work, the computers only cause that the delegations spend much more time for the perfection of the layout of their translations.

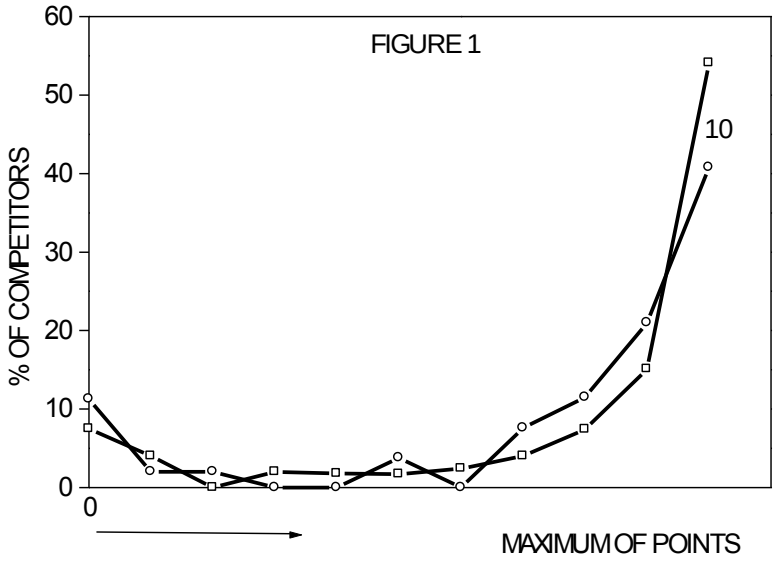
In the past there were long discussions about the difficulty of the theoretical tasks. The working group of Neusiedl 1994 emphasized that the authors of the tasks should take into account that the competitors are not the university students and are at the age of about

17 (many problems could be avoided if the authors would have some experience in the IChO). The tasks should be intelligent, not repetitive, brain-teasing; they should be modern but in a cautious way. They may be difficult, but the difficulty should not be already in the first sentence of a task but should be increasing during the task (a part of the competition must be at normal high school level). Problems consisting of different parts which are connected with each other should enable nearly every student to solve the starting question, whereas the last questions of a task should only be answered by the best students.

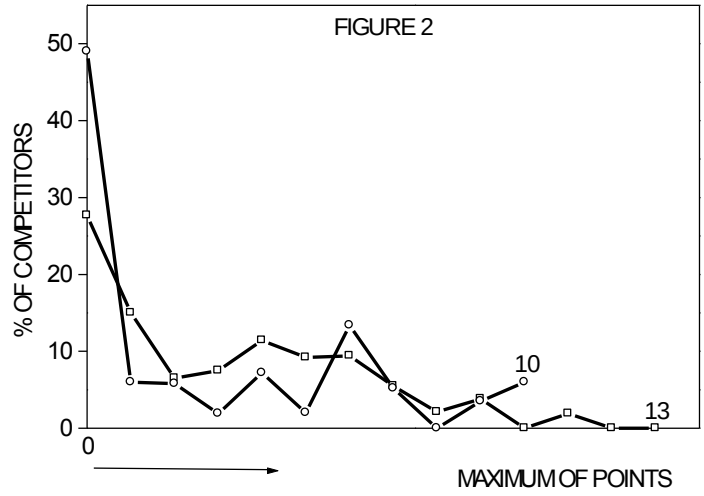
It is not very meaningful to judge the quality of a certain IChO task by showing the average of points which students got for this task. For example, a good average of 50% could be obtained for a bad task where a half of the students got zero points and the other half full points. The evaluation of the “perfect“ task should create something like a Gauss-curve if the number (or percentage) of participants is shown against the number of gained points.

A. Sirota brought such diagrams in a lecture held at the IChO in Frankfurt 1984.

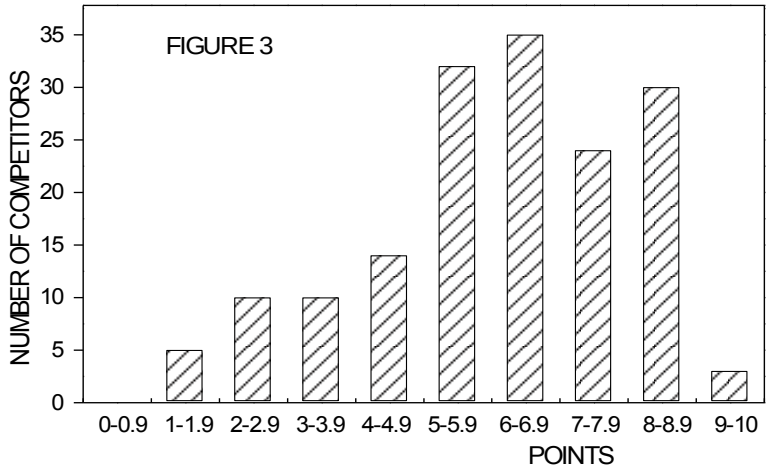
The first diagram (Fig. 1) shows two IChO-tasks which were very easy and had no building-up but only one question at the end of the task.



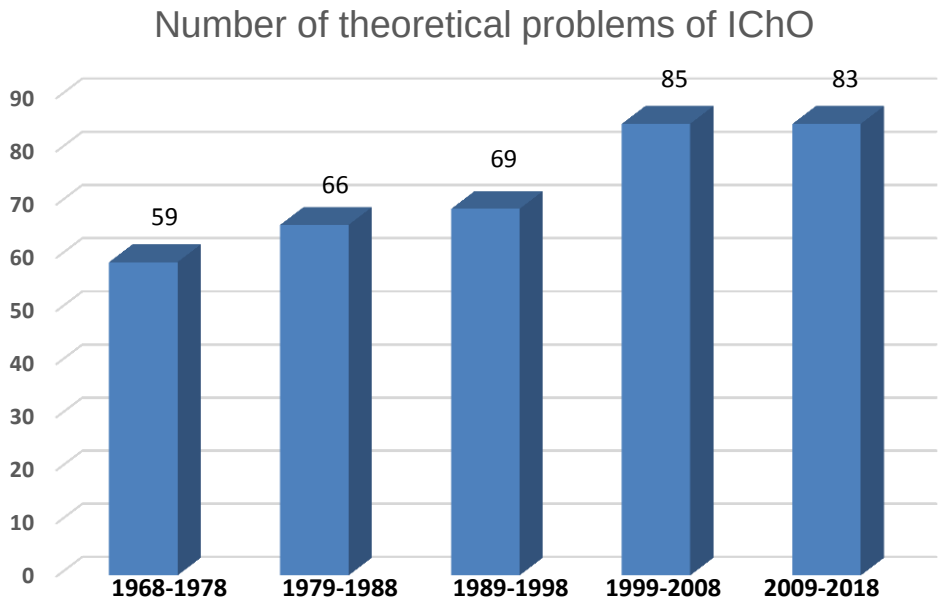
The second diagram (Fig. 2) is typical for a task with difficult questions which are depending on each other.



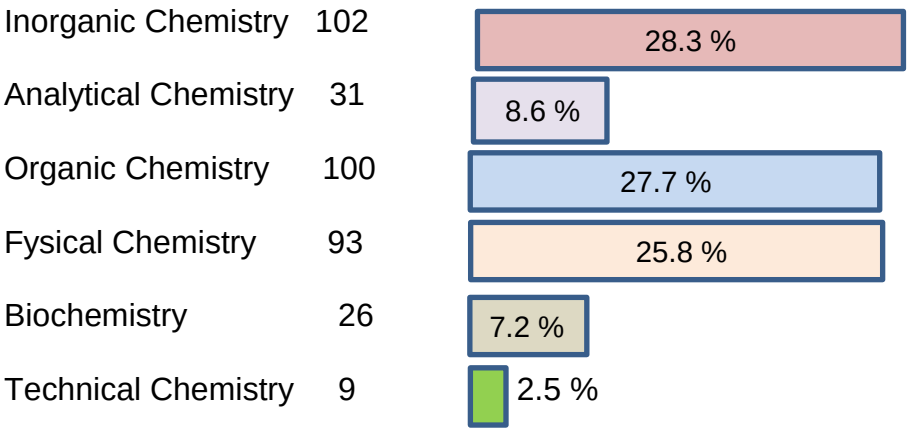
In general, the situation has improved in the course of the years. An example of a good task with increasing difficulty of questions which depended partially on each other was the problem No 5 in the 27th IChO. It is illustrated in the Fig. 3.



A task should not require a lot of time for multiple calculations (if the idea of a task can be shown with 2 substances, do not use 5). The total volume of the competition should not be too big, as the IChO should determine the best, not the fastest student. There should be a balance between the classical areas of chemistry. The set of theoretical tasks should contain one task of general chemistry, physical chemistry, inorganic chemistry and organic chemistry at least.



Totally 362 theoretical tasks were set from the 1st up to the 50th IChO. The total numbers of the tasks from some fields of chemistry are shown in the following scheme:



But if you look only at the last IChOs there exists, roughly estimated, an equilibrium between inorganic, organic and physical chemistry. Of course, in many cases it is not easy to say unambiguously to which field of chemistry a task belongs.

The working groups of Sofia 1992 (and Warsaw 1996) divided these fields in 379 (349) topics and established something like a sylabus for the IChO. Each topic was classified:

Group 1: topics are included in the overwhelming majority of secondary school programs.

Group 2: topics are only partially included in the school programs but it is expected that Olympiad level students of every country are introduced to these topics.

Group 3: topics have university level and must be dealt in the preparatory problems.

In Montreal (1997) the jury decided to reduce the number of preparatory problems of the higher levels.

The recommendations from the workshops of Sofia, Neusiedl and Warsaw caused an improvement: good and balanced tasks from every field of chemistry occurred. But it is

not easy to invent tasks which do not require only the pure knowledge of the students, i.e. which are challenging without using much of the university level. The working group of Amsterdam 1990 argued that at least one of the tasks should be outside the usual frame, unexpected, tickle the imagination or fantasy of the candidates. So the student could not solve the problem with already obtained knowledge. It is certainly difficult to produce such tasks and the past IChOs gave prove for it: only very seldom a task has appeared which would fulfill these requirements.

It is a tightrope walk for the authors to make tasks which are similar to the preparatory problems but not too similar. It is the aim of the competition to test the ability of the student to apply a basic knowledge of chemistry to new problems, showing brain operations and chemical thinking. Thus it may happen that a student knowing all the preparatory problems by heart may not be successful when solving the competition tasks.

Summing up it can be said that the theoretical IChO-tasks became more complex, more difficult (but this difficulty is no longer increasing), and got a better didactic quality (which allows a better distribution of the points). This is a merit of the jury, of the Steering Committee and especially of the Working Groups which met every second year.

Milestones for the theoretical part of the IChO competition:

1. Based on the IChO regulations (guidelines for mentors, guidelines for organizers):
   - §7 ⇒ international jury responsible for the final text
   - §10 ⇒ prep problems as basis for the (theoretical competition)
   - §10 ⇒ 4 - 5 hours
   - §13 ⇒ length, number of characters

     (The total length of the theoretical or experimental tasks, including answer sheets, should be kept to a minimum and not exceed 25,000 characters.)

   - §14 ⇒ 60 % of the points for the theoretical part

2. Positive consequences for the competition:
   - 1984: English as the only discussion language
   - 1988: distribution of tasks prior to the jury session
   - Early nineties: change of theoretical and practical competition
   - 1991: Discussion with authors prior to the jury session
   - 1992: computers instead of typing machines
   - 1994: “blue” and “red” points
   - 1997: split sessions in the jury
   - 2002: full day for translation

3. Characteristics for a “perfect” theoretical task
   - is not too short, not too long, has several parts which help to some extent to solve the whole problem,
   - is not repetitive,
   - starts easy, ends very difficult (so that nobody gets no marks, only very few full marks),

- different (difficult) parts are not connected. If so: double punishment should be avoided and there must be possibility to continue,
- contains chemical parts, mathematical parts, diagrams, structures….,
- covers different fields of chemistry,
- does not require only fact knowledge (overtraining!),
- requires thinking, imagination and fantasy,
- is easy to grade so that arbitration is not necessary.

Thanks to H. Zechmann and M. Kerschbaumer for their help.

Compiled and edited by A. Sirota
(IChO Intern. Information Centre)