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SIMPLE AND LOW-COST CHEMICAL KITS FOR SCHOOL LABORATORIES

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The necessity of an experimental teaching media for chemistry is too obvious to need any justification. The success of any modern chemistry teaching programme, therefore, rests upon the presentation of the concepts and ideas of the subject through experiments. A greater challenge to chemistry teaching improvement, particularly in developing countries, however, is to devise experiments which bring out the fundamental ideas of the subject, using chemicals and equipment within the easy reach of school laboratories.

As most of the commercially available sets of experiments for teaching chemistry in school or kits are relatively expensive, we were trying to develop at the UNESCO Pilot Project for Chemistry Teaching in Asia (Bangkok), a set of experiments in the form of low-cost kits, which could serve both teachers and students. Our idea was not to try to develop experiments for covering all topics of chemistry teaching at primary and secondary level, but to select some interesting topics, which could represent important topics of modern chemistry teaching and could encourage the teachers in their creative activities.

The selected topics were discussed with leading persons in chemistry teaching programmes and the individual topics and experiments consulted at the Project with the international staff from developed and developing countries. The selected subjects were: "Stoichiometry and Compound Formation", "Chemical Equilibria", "Rate of Chemical Reactions", and "Nuclear Science".

Two of the mentioned topics ("Stoichiometry and Compound Formation" and "Chemical Equilibria") were the main themes of the Summer and Winter Institutes organized at the Project in 1967 and 1968 for a group of about 35 teachers from secondary schools and Teacher Training Colleges in Thailand. During the Summer and Winter Institutes the participants were performing the experiments using relatively sophisticated equipments (e.g. potentiometers, spectrophotometers, etc.) which are not available at most of the schools in developing countries and therefore on the basis of the experiences, with the Summer and Winter Institutes, most of the experiments were modified in order to use as simple equipments as possible and to save as many chemicals as possible and finally the first two experimental kits on "Experiments on Chemical Equilibria" and "Experiments on Compound Formation" were set up. As far as possible, the experiments have been performed in a semi-micro scale, using small amounts of

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chemicals and small volumes of solutions of reagents, in order to lower the cost of the experiments when repeated with a larger group of students. Droppers are used instead of pipettes and burettes, eye drops flasks are used for storing the solutions and small plastic bottles for storing solid chemicals. The price of the kit, including both chemicals and equipment may vary from country to country, but in general, the average cost would not exceed \$25.

Into each kit the Instruction booklet is enclosed. This booklet represents the key part of the kit, contains the pictures of all required items, list of chemicals and set of selected experiments. The purpose of each experiment is outlined in the beginning and this is followed by a description of the experimental details. Important points of theory behind the experiment are also given at the end of the experiment to make the discussion of the results worthwhile. However, for a more detailed discussion of the theory, the teacher is referred to "Compound Formation, a Teachers' Digest, Vol. 1,2" and "Chemical Equilibria, a Teachers' Digest" a copy of which is also provided with the kit. These digests contain both lectures and workshop reports from the Summer and Winter Institute.

All experiments included into the kits were tested by secondary school teachers and by secondary school students and the final modifications of both procedures and texts of the instruction booklets were made taking into account their comments.

The level of the experiments was meant for upper grade of secondary schools, or for pre-university level. Wherever possible, modern methods of studying the course of the reactions, e.g. method of continuous variation, thermometry, use of ion-exchangers, paper chromatography, non-aqueous media, use of EDTA compounds were incorporated into the frame work of the kit.

Types of experiments included into the kit can be illustrated in the following list:

"Experiments on Chemical Equilibria": I. Acid-base Equilibria: I-1 Acid-base indicators, I-2 Hydrolysis of salts, I-3 An acid-base neutralization reaction, I-4 Buffer action, I-5 Acid-base neutralization curves, I-6 Common ion effect, II: Equilibria Involving Ion Exchange, II-1 Determination of concentration of sodium ions in solution (using a cation exchange resin), II-2 Determination of

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concentration of nitrate ions in solution (using an anion exchange resin), II-3 Freeing water of dissolved salts (using a combination of cation and anion exchange resins), II-4 Separation of iron, cobalt and nickel ions (using an anion exchange resin), III. Oxidation Reduction Equilibria: III-1 The reaction of sodium arsenite with iodine, III-2 Verification of predictions from half cell potentials, III-3 Oxidation states of vanadium, a transition element, III-4 The phenomenon of metallic corrosion, IV: Solubility and Complex Ion Equilibria, IV-1 Effect of temperature on equilibrium, IV-2 Effect of partial pressure of a gas on solubility equilibrium, IV-3 The principle of solubility product, IV-4 Reaction of magnesium metal with a dilute acid, IV-5 Influence of complexing agents on equilibria, IV-6 Determination of hardness of water by a chelatometric method using EDTA, Appendix: Mole and Molarity.

"Experiments on Compound Formation": I. Action of heat on compound, II. Stoichiometry of lead iodide formation, III. Reaction of metal ions with aqueous solutions of sodium hydroxide and ammonia, IV. Precipitation of sparingly soluble salts from aqueous solution, V. Chemical properties of some gases, VI. Preparation and interconversion of copper (II) compounds, VII. Oxidation reactions with potassium permanganate, VIII. Colorimetric study of iron (III) complexes, IX. Reaction of magnesium with hydrochloric acid, X. Thermometric study of the reaction of strong acids with strong bases, XI. Acid-base reactions in non-aqueous media. Answers to questions, Appendix: Mole and Molarity.

The list of items and chemicals required for the experiments was consulted what concerns their availability, with members of UNESCO Study Groups in several Asian countries, before finalizing the content of the kit. Most of them are easily available in each country from local sources so that copies of the kits could easily be produced in each country, using the prototype of the kits available at the Project or using the pictures of items and list of chemicals, which can be found in the instruction booklets. A film loop, describing the kit and its use is now being prepared at the Project.

A new similar prototype of the kit on "Experiments on Rate of Chemical Reactions" is now being developed at the Project and another one on "Nuclear Science Experiments" is expected to be completed by the end of this year. The

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cost of the latter one will certainly be higher, mainly due to the subject which requires special measurement technique for the use of radioisotopes.

The kits with selected experiments should serve as an example for teachers and should not be considered as a standard or standardized teaching aid. They were meant as additional programme, which could, anyhow be included into the existing curricula. Success in teaching will always depend not entirely on the facilities of the school laboratories, but on the teacher's interest in teaching. This holds also for the described prototypes of kits, which should encourage the teacher to continue in developing similar experiments and support his creative ability. Last, but not least, the kit should encourage the teachers to experiment at schools, where the laboratory facilities for experimenting are not yet available. The mass production of copies of these and similar kit for a very low-cost could help the schools in most developing countries, and therefore, probably, a group of specialists should select among prototypes of existing kits and kits, which are being developed, those, which could be produced commercially, to lower the cost of the prototype. In-service course could be organized in each country to test the use of the kits and extend the content of the kit by developing new experiments.

References:

"Experiments on Chemical Equilibria" (An instruction booklet) UNESCO Chemistry Project, Bangkok, 1968.

"Experiments on Compound Formation" (An instruction booklet) UNESCO Chemistry Project, Bangkok, 1969.

"Chemical Equilibria - A Teacher's Digest" (Proceeding of the Summer Institute) UNESCO Chemistry Project, Bangkok, 1968.

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