Heliocentris

Dr FuelCell™
Solar Hydrogen and Fuel Cell Technology

Educational products for physics and chemistry lessons

New England Academic Representative:

Technology Education Concepts

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Dr FuelCell™

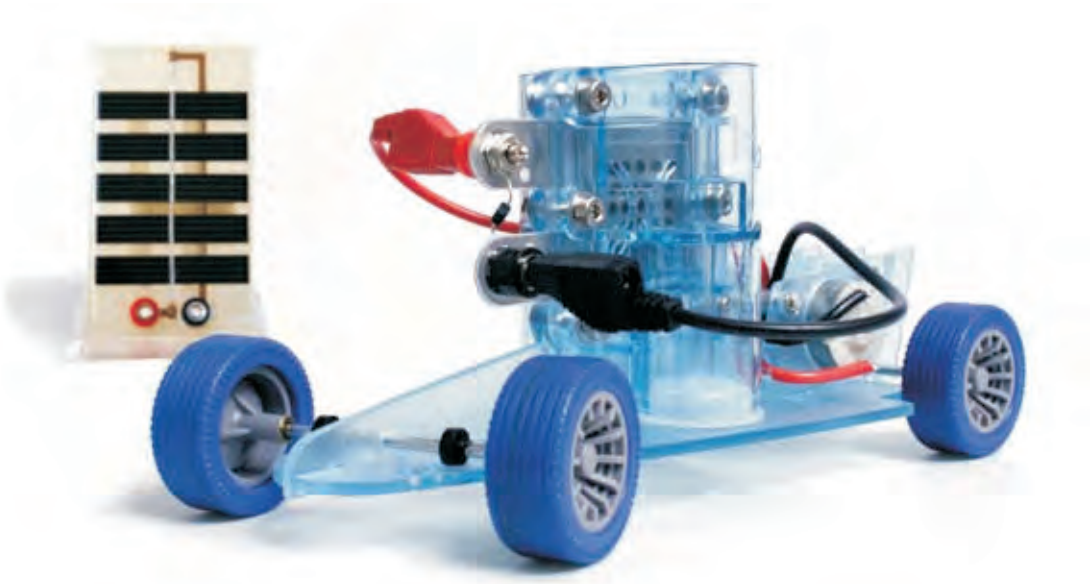
Renewable energies as well as their technologies have become a permanent fxture in our lives and will play an even greater role in the future. The preparation of your students for the future is in your hands.

With the Dr FuelCell™ products for solar hydrogen and fuel cell technology, Heliocentris would like to provide you with an aid that helps bring your students closer to future technologies and achieve the desired learning efect in a fun flled manner. The simple structure of the products promotes comprehensibility and piques interest in scientifc felds like physics and chemistry. Documentation with instructions for experimentation that has been developed especially for educational purposes facilitates interaction with the Dr FuelCell™ products and slowly, purposefully guides your students towards learning success.

You beneft from over ten years of experience with teachers and students in the feld of solar hydrogen and fuel cell technology.

Our products stand for:
- Curricular relevance and didactic quality
- The highest quality products and robust construction
- Easy set-up and operation
- Diverse applications
- Documentation that is appropriate for target age groups

Dr FuelCell™ Educational Products



Grades 5 10

Experiments

▲ Auto chassis with solar module

▲ Reversible fuel cell with load measurement box

▲ Hand generator with reversible fuel cell

Dr FuelCell™ Model Car

Model car with reversible fuel cell

▶ Dr FuelCell™ Model Car

Pique your students' interest in fuel cells with this fascinating car. Increase your students' awareness for renewable energies through curriculum-related experiments with an exciting new technology. Powered by water and sunlight, the model car represents an interesting and simple gateway into solar hydrogen and fuel cell technology. Through practical experiments your students gain hands-on experience in the relationships between energy conversion, storage and consumption. Developed for daily use in the classroom, the Dr FuelCell™ Model Car is distinguished by its easy manageability and through its flexible and robust construction and is suitable for both working in groups and individually.

Included in the package is a reversible fuel cell, which works as both electrolyzer and fuel cell. As an electrolyzer the cell uses the energy supplied through a solar module or hand generator to separate water into oxygen and hydrogen. In fuel cell operation the stored hydrogen is converted into electrical energy and thus drives the electric motor of the model car. Encourage your students to explore fuel cell technology with the Dr FuelCell™ Model Car and give them a head-start in this area of development.

▶ Areas of Application

The Dr FuelCell™ Model Car can be used for both demonstration purposes and in practical instruction. The interest of your students is promoted through demonstration and close observation. Numerous experiments enable your students to practically apply the knowledge and take part themselves. In this way, curriculum-relevant themes in physics and chemistry, such as electrolysis, solar energy, fuel cells or energy conversion, generation, storage and consumption can be taught in a fun filled manner. You will have fun teaching and your students will have fun learning!

▶ Curriculum Aspects

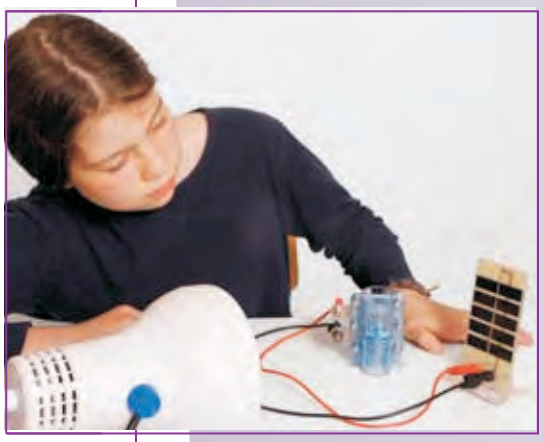
Many diferent facets of physics and chemistry curricula can be taught on the basis of the Dr FuelCell™ Model Car:

- Water – element or compound
- Energy storage and energy transfer
- Experimenting, recording and evaluating
- Paths of the current – circuit systems
- Planning and execution of project-based work

▶ Languages available

- English
- German
- French
- Spanish
- Turkish
- Arabic
- Japanese
- Korean

Product Options



▶ Dr FuelCell™ Model Car Complete
- Reversible fuel cell with graduated gas storage cylinders
- Solar module
- Hand generator
- Load measurement box
- Car chassis
- Cable, stop watch
- Distilled water
- Dr FuelCell™ Model Car Instruction Material (see p. 10)

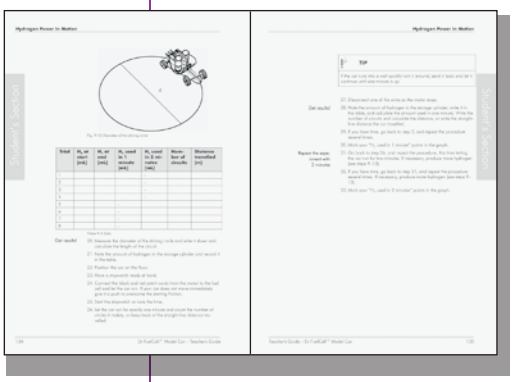
Item No. 354

▶ Dr FuelCell™ Model Car Demo
Like Dr FuelCell™ Model Car Complete, but without load measurement box and without hand generator

Item No. 352

Experiments

(excerpt)
- Solar power dependent on the incident angle of the sun
- Electrolysis
- Hydrogen power in motion: friction, work, power, energy
- The hybrid concept: hybrid car with hydrogen technology



▲ Teacher's Guide

▲ Dr FuelCell™ Model Car Instruction Material (see p. 10)

Grades 9-12

Experiments

▲ Solar module with electrolyzer

▲ Solar module with load measurement box

▲ Electrolyzer and fuel cell with load measurement box

Dr FuelCell™ Science Kit

Solar Hydrogen Technology Science Kit

▶ Dr FuelCell™ Science Kit

Promote your students' interest in renewable energies and future technologies through independent experimenting. With the Dr FuelCell™ Science Kit your students can practically experiment with what they were taught in theory – independently or in small groups. The experimental reproduction of a complete energy cycle provides your students with the opportunity to grasp the overall concept of renewable energies as well as closer investigation of individual technologies. Included in the package is a solar module, which provides energy for the electrolyzer in order to produce hydrogen. The hydrogen is temporarily stored in measuring cylinders and converted into electrical energy in the fuel cell. A load measurement box offers the possibility of measuring current and voltage with different loads. Also included are 20 ready-made experiments, which demonstrate the sustainable utility of fuel cells and hydrogen in both chemistry and physics lessons. In order to immerse even further into fuel cell technology, an expansion of the Dr FuelCell™ Science Kit is possible with a methanol and a dismantlable fuel cell. Give your students the opportunity to share in the development of renewable energies.

▶ Areas of Application

The Dr FuelCell™ Science Kit is the perfect opportunity to strengthen and demonstrate theoretical knowledge through experimentation. Students are encouraged to think through independent experiments and their curiosity for renewable energies is inspired. Ample curriculum-oriented documentation and coordinated experiments are appropriate for lessons in both chemistry and physics, through which students might, for example, gain a better understanding of the chemical-physical processes of fuel cells. Let your students experiment!

▶ Curriculum Aspects

Many different facets of physics and chemistry curricula can be taught on the basis of the Dr FuelCell™ Science Kit:

- Principle of molecules
- Chemical reactions
- Acceleration of reactions
- Thermodynamics
- Electrochemistry
- Measurement and interpretation of characteristic curves
- Planning and execution of scientifc experiments

The four books for solar hydrogen technology provide a supporting function. Along with the numerous experiments they contain additional background information for this future technology.

Product Options

▶ Dr FuelCell™ Science Kit Complete

- PEM fuel cell
- PEM electrolyzer with graduated storage cylinders
- Solar module
- Load measurement box
- Stop watch
- Cable, hoses, hose clamps
- Storage box
- Dr FuelCell™ Science Kit Instruction Material
- CD-ROM: Hydrogen – Energy for Tomorrow
- Dismantlable fuel cell
- Methanol fuel cell
- Illustrated assembly instructions

Item No. 355

▶ Dr FuelCell™ Science Kit Basic

Like Dr FuelCell™ Science Kit Complete, but without dismantlable and methanol fuel cell

Item No. 350

▶ Supplement: Dismantlable fuel cell

- PEM fuel cell
- Air or oxygen operation
- 2 membranes with diferent catalyst coatings
- Plug-in resistor

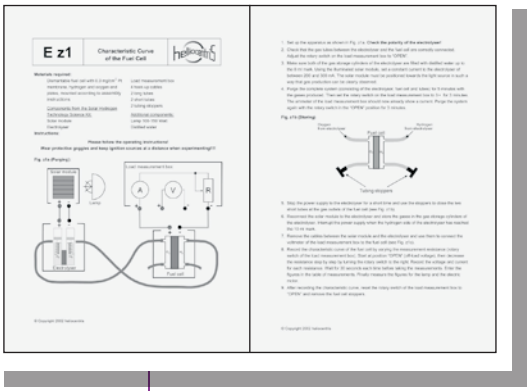
Item No. 353

▶ Supplement: Methanol fuel cell

- Methanol fuel cell
- 3 storage cylinders (without methanol solution)

Item No. 357

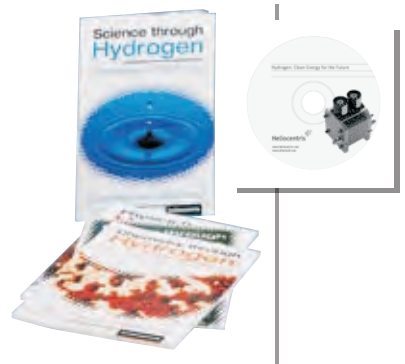
Experiments



▲ Teacher's Guide

(excerpt)

- Current/voltage curves
- Electrolysis
- Characteristic curve of a fuel cell, solar cell
- 1. Faraday's Law
- Faraday and energy coefcient of an electrolyzer, of a fuel cell
- Thermodynamics: Electrochemica processes
- Series and parallel connection of solar cells, fuel cells
- Water = 2 parts hydrogen + 1 part oxygen



▲ Dr FuelCell™ Science Kit Instruction Material (see p. 11)

Grades 9 12

Dr FuelCell™ Professional

Fuel Cell Demonstration and Practice Module

Dr FuelCell™ Professional

With the aid of the Dr FuelCell™ Professional, solar hydrogen and fuel cell technology can be presented and taught with out standing results. Large modular components and displays that are clear and easy to read are ideally suited for presentations in front of the class or larger groups.
The diferent modules through which a complete energy circuit is represented are found in a stable frame. The energy created by the solar module is used for the electrolysis and water is separated into hydrogen and oxygen in the electrolyzer. The gases are stored in measuring cylinders. If electrical energy is required, the gases in the double fuel cell are combined again to form water, whereby electricity is generated. Both the electrical series and parallel connection of the individual cells can be demonstrated with the double fuel cell. The load module and the measuring unit enable the acceptance of diferent current fows. You use a simple system that does not require any additional chemicals in order to be able to experiment and present in front of your students.
The Dr FuelCell™ Science Kit makes the perfect supplement to this wall panel system in order to have your students conduct purposeful experiments.

Areas of Application

Through the simple structure and fast commissioning, the Dr FuelCell™ Professional is out standingly suited as a demonstration tool for teaching in order to conduct experimental demonstrations in front of large groups. It is also an experiment module that can be used by students during a practicum. You can descriptively convey basic knowledge of fuel cells and solar hydrogen technology in all scientifc and technical felds in a clear and demonstrative manner!

Curriculum Aspects

Many diferent facets of the curricula of physics, chemistry and technology can be presented on the basis of Dr FuelCell™ Professional:

- Principle of molecules
- Chemical reactions
- Acceleration of reactions
- Thermodynamics
- Electrochemistry
- Measurement and interpretation of characteristic curves

Independently of this, the main emphasis of the instruction can be shifted as needed. You can choose from 20 well-prepared basic experiments – and modify them as needed or design your own individual experiments.

Product Options

▶ Dr FuelCell™ Professional Complete

- Solar module
- PEM electrolyzer with graduated gas storage cylinders
- PEM double fuel cell
- Load module
- Measuring unit
- Frame
- Hoses, hose clamps, cable
- Dr FuelCell™ Science Kit Instruction Material
- CD-ROM: Hydrogen – Energy for Tomorrow
- Lamp with illuminant

Item No. 392

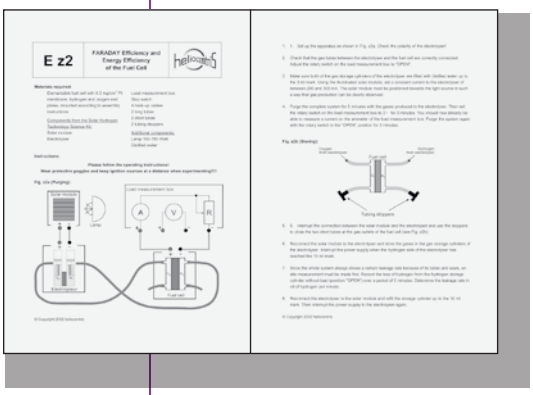
▶ Dr FuelCell™ Professional Demo

Like Dr FuelCell™ Professional Complete, but without measuring unit
Item No. 391

▶ Supplement: measuring unit

Demonstration measuring unit for current and voltage
Item No. 379

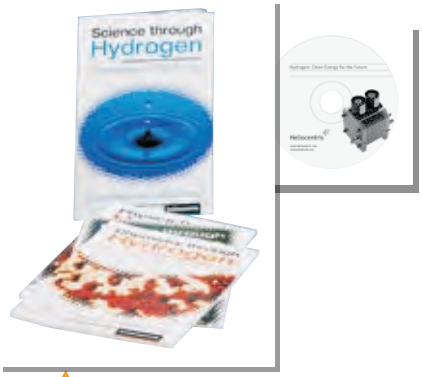
Experiments



▲ Teacher's Guide

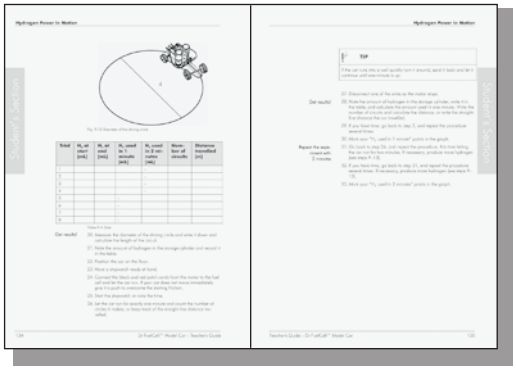
(excerpt)

- Current/voltage curves
- Electrolysis
- Characteristic curve of a fuel cell, solar cell
- 1. Faraday's Law
- Faraday and energy coefcient of an electrolyzer, of a fuel cell
- Thermodynamics: Electrochemical processes
- Series and parallel connection of fuel cells
- Water = 2 parts hydrogen + 1 part oxygen



▲ Dr FuelCell™ Science Kit Instruction Material (see p. 11)

▲ Dr FuelCell™ Model Car Instruction Material



▲ Teacher's Guide

▲ Quick Guide

Dr FuelCell™ Model Car Instruction Material

▶ Instruction Material

The ring binder contains all materials, neatly structured. It is subdivided into three parts:

- A two-page **Quick Guide** facilitates you with the quick introduction to solar hydrogen and fuel cell technology.
- The **Teacher's Guide** contains numerous experiments for grade levels 5-10, which are additionally divided according to age group and degree of difficulty. In this way, a quick orientation is ensured. In order to additionally ease your work, the individual pages with experimental set-ups or experimental instructions can also be used as master copies.
- Potential questions are explained in detail in the **Instruction Manual**. They help you use the Dr FuelCell™ Model Car and prepare for additional experiments. (87 pages)

All three documents including all experiments are additionally available in PDF format, supplied on a CD-ROM for easy processing. This way the preparation of lessons is only a matter of minutes!

▶ Scope of Experiments

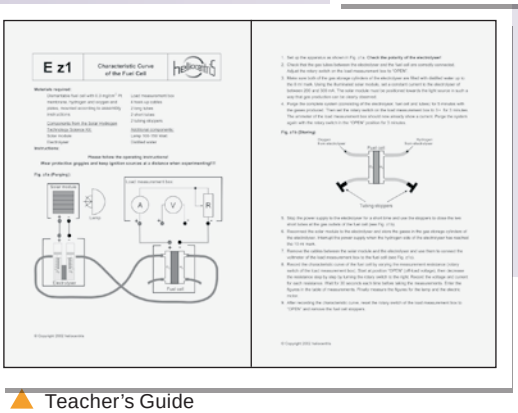
Each experiment description contains one part with background information about themes being covered, one part for teachers and one part for students. The part for teachers contains all information for the experiment, all assignments and solutions as well as the complete experimental results. In addition to the experiment description, the part for students contains models for the collection of measurement data and the appropriate problems for the age level.

Fuel cells use the chemical energy from hydrogen in order to create clean and efcient electrical current. Therefore, the potential of hydrogen fuel cells is enormous, whether as a signifcant component of a future reliable energy supply or as a possibility to reduce the creation of greenhouse gases, air pollution and advancing changes in global climate.
You can present diferent facets of the curriculum on the basis of this technology:

- Water – element or compound
- Energy storage and energy transfer
- Experimenting, recording and evaluating
- Paths of the current – circuit systems
- Planning and execution of project-based work

▲ Dr FuelCell™ Science Kit Instruction Material

Dr. Henrik Colell
Co-author and editor of the "Hydrogen – Energy for Tomorrow" series
"The demand for these textbooks was all the more urgent as there had been no teaching material available to schools on the highly topical and widely discussed subject of hydrogen and fuel cell technology."



▲ Teacher's Guide

▲ CD-ROM: Hydrogen – Energy for Tomorrow

Dr FuelCell™ Science Kit Instruction Material

Course Program for Secondary Education

▶Instruction Material

The **4-volume complete package** for secondary education has been developed together with the Dr FuelCell™ Science Kit and Dr FuelCell™ Professional and is already included with them. The **experimental lessons** cover a broad spectrum of material from physics and chemistry curricula. The student instruction sheets put students in position to conduct their experiments independently. They are suitable for experiments in individual and group work as well as for projects or assignments. The lessons ofer a wide range of possibilities for the analysis and interpretation of measurement data. Detailed teaching instructions supplement the student instruction sheets.

The **worksheets** consist of brief, specialized texts and written assignments and can be worked out during the instruction or as homework. They support the students' ability to compose scientifc texts and work on assignments for this purpose.

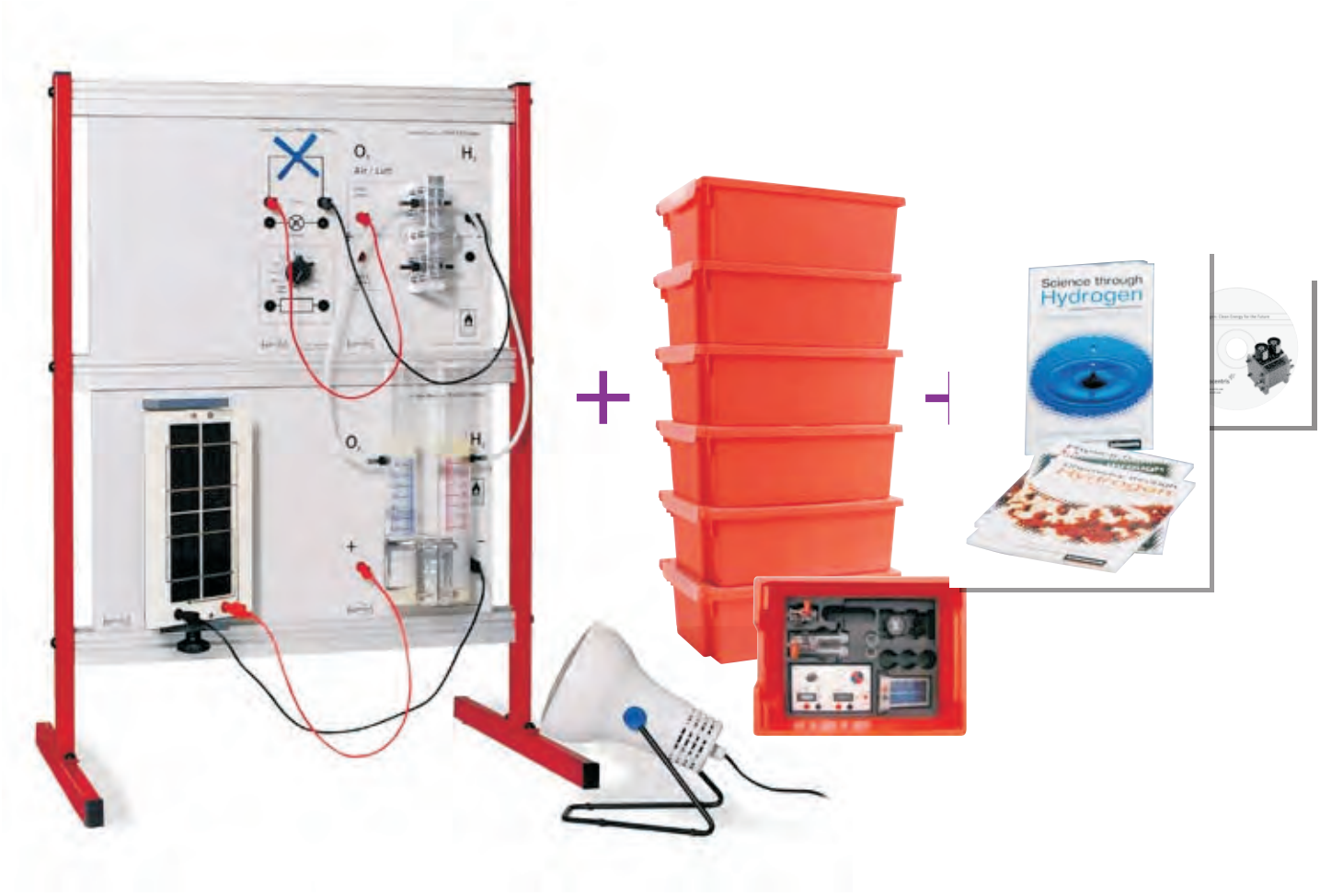
The fourth book **"Principles and Applications"** comprises twelve specialized texts, which can be used independently of one another during lessons. They show how diferently-constructed fuel cells can fulfll the diferent requirements of the home, transportation and industry and examine the question of how hydrogen technology can be used successfully in the coming years.

Experiment examples:

- Current/voltage curves
- 1. Faraday's Law
- Electrolysis
- Characteristic curve of a fuel cell, solar cell
- Dependence of photocurrents on the distance and incident angle of the light source
- Faraday and energy coefcient of an electrolyzer, of a fuel cell
- Thermodynamics: Electrochemical processes
- Series and parallel connection of solar/fuel cells
- Water = 2 parts hydrogen + 1 part oxygen

▶CD-ROM

The supplied CD-ROM contains two digital videos and two PowerPoint presentations with accompanying text. In both forms of media the principles and the use of solar hydrogen technology are explained and two experiments are conducted with the Dr FuelCell™ Science Kit.



Dr FuelCell™ Classroom Bundle 1

1x Dr FuelCell™ Professional Demo
+ 6x Dr FuelCell™ Science Kit Basic
+ 1x Dr FuelCell™ Science Kit Instruction Material
+ 1x CD-ROM

Dr FuelCell™ Science Kit and Professional are based on the same didactic concept. Therefore they are an ideal combination for demonstrating experiments and then having them conducted by the students. Based on past experience, the experiments are best conducted in groups of three to four persons. Motivate your students to execute what was just demonstrated themselves!

▶ Dr FuelCell™ Classroom Bundle 1
- 1x Dr FuelCell™ Professional Demo
- 6x Dr FuelCell™ Science Kit Basic (without instruction material)
- 1x Dr FuelCell™ Science Kit Instruction Material
- 1x CD-ROM: Hydrogen – Energy for Tomorrow

Item No. 915

▶ Supplemental Set: 6x lamps with illuminant
For the “simulation of the sun” we recommend the appropriate light source.
Item No. 917

Dr FuelCell™ Classroom Bundle 2

6x Dr FuelCell™ Science Kit Basic
+ 1x Dr FuelCell™ Science Kit Instruction Materi
+ 1x CD-ROM

Dr FuelCell™ Classroom Bundle 2
- 6x Dr FuelCell™ Science Kit Basic (without instruction material)
- 1x Dr FuelCell™ Science Kit Instruction Material
- 1x CD-ROM: Hydrogen – Energy for Tomorrow

Item No. 916

Supplemental Set: 6x lamps with illuminant
For the "simulation of the sun" we recommend the appropriate light source
Item No. 917

Dr FuelCell™ Classroom Blundle 3

6x Dr FuelCell™ Model Car Complete
+ 1x Dr FuelCell™ Model Car Instruction Material

Dr FuelCell™ Classroom Bundle 3
- 6x Dr FuelCell™ Model Car Complete (without instruction material, with quick guide)
- 1x Dr FuelCell™ Model Car Instruction Material

Item No. 926

Supplemental Set: 6x lamps with illuminant
For the "simulation of the sun" we recommend the appropriate light source
Item No. 917

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I want to learn more about these products:

- ◯ Dr FuelCell™ Model Car
- ◯ Dr FuelCell™ Science Kit
- ◯ Dr FuelCell™ Professional
- ◯ Dr FuelCell™ Instruction Material
- ◯ TekStak™
- ◯ Please send me your product catalog for technical training.

Newsletter

◯ In order to remain up-to-date about the development of fuel cells, customer projects and Heliocentris, please include me in the distribution of your email newsletter.

My Comments