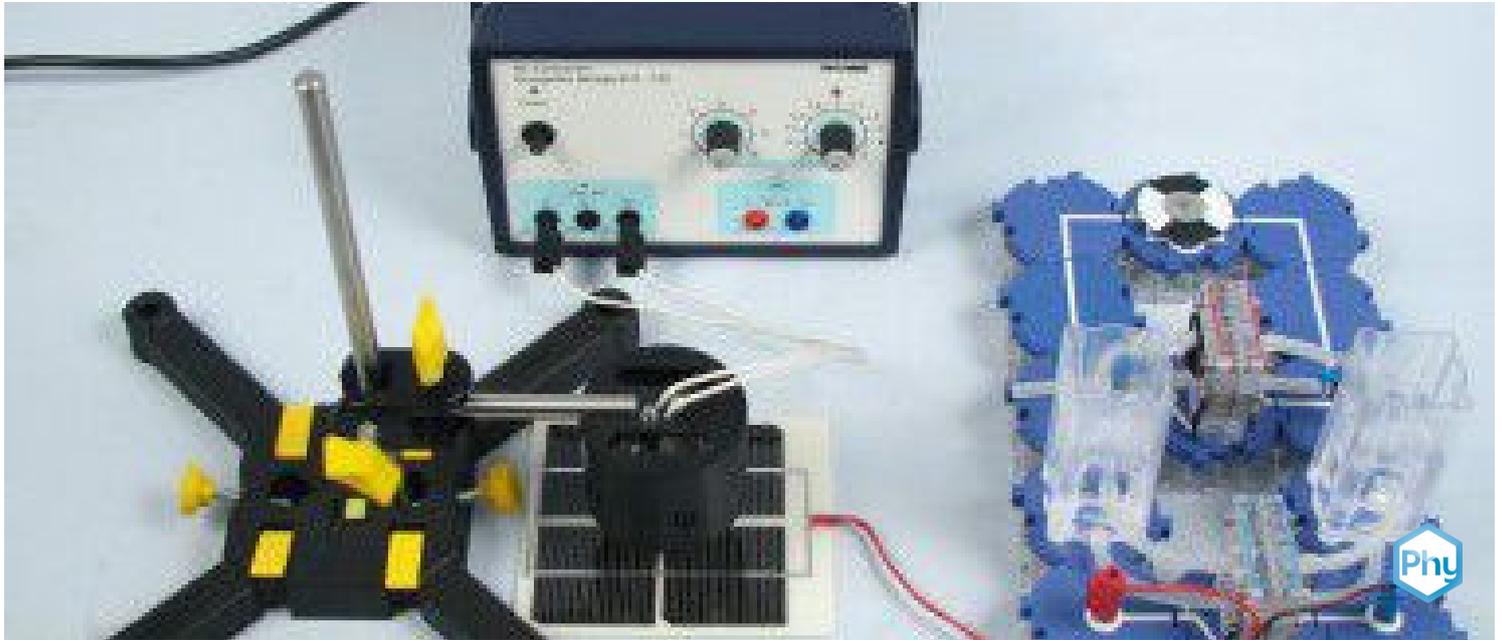


Green Hydrogen: Solar-Hydrogen System



Physics

Energy

Renewable energies: Water



Difficulty level

easy



Group size

1



Preparation time

10 minutes



Execution time

10 minutes

This content can also be found online at:

<https://www.curriculab.de/c/68e49b33c7bbc00002ae8ac8>

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Teacher information

Application

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Experimental setup

While coal, natural gas and crude oil will be used up at some point in the not too distant future, it is estimated that the sun will continue to exist in the form we know it for around 5 billion years. Solar energy can be utilised, but the problem is that the energy is not always available when it is needed. Storage is therefore necessary so that the energy can be utilised around the clock. Hydrogen could take over this task in the future.

Other teacher information (1/2)

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Prior knowledge



Students should already know the chemical composition of water and be familiar with the chemical reaction between hydrogen and oxygen.

Principle



A solar battery is irradiated with the aid of a halogen lamp to determine whether this energy is sufficient to operate the hydrogen system and thus also the engine.

Other teacher information (2/2)

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Learning objective



Pupils should understand how water can be broken down into its components using solar energy.

Tasks



1. Check whether a hydrogen system can be operated with solar energy.

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Student information

Motivation

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Green hydrogen is produced through the electrolysis of water, with the electricity required coming from solar cells. In the process, water (H_2O) is split into hydrogen (H_2) and oxygen (O_2). If the energy for this process comes exclusively from renewable sources such as solar energy, no CO_2 emissions are produced. This hydrogen is therefore considered 'green' or environmentally friendly, as it is produced without fossil fuels and CO_2 emissions. The end product, green hydrogen, can then be used as an emission-free energy source in various applications.



Illustration of a solar system

Equipment

| Position | Material | Item No. | Quantity |
|----------|--|----------|----------|
| 1 | Beaker, Borosilicate, low-form, 400 ml | 46055-00 | 1 |
| 2 | Motor with indicating disc, SB | 05660-00 | 1 |
| 3 | Junction module, SB | 05601-10 | 2 |
| 4 | Angled connector module, SB | 05601-02 | 4 |
| 5 | Straight connector module, SB | 05601-01 | 2 |
| 6 | Digital stopwatch, 24 h, 1/100 s and 1 s | 24025-00 | 1 |
| 7 | Solar battery, 4 cells, with cable and connectors | 06752-22 | 1 |
| 8 | Support base, variable | 02001-00 | 1 |
| 9 | Halogen lamp with reflector, 12V / 20W | 05780-00 | 1 |
| 10 | Mount for halogen lamp with reflector | 05781-00 | 1 |
| 11 | Gas storage, SB | 05666-00 | 2 |
| 12 | PEM electrolyser, SB | 05665-00 | 1 |
| 13 | PEM fuel cell for hydrogen/oxygen and hydrogen/air operation, SB | 05664-00 | 1 |
| 14 | Boss head | 02043-00 | 1 |
| 15 | Support rod, stainless steel, l = 250 mm, d = 10 mm | 02031-00 | 1 |
| 16 | PHYWE Power supply, 230 V,DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A | 13506-93 | 1 |
| 17 | Silicone tubing, inner diameter 3 mm | 39292-00 | 1 |
| 18 | Pinchcock, width 10 mm | 43631-10 | 2 |

Safety information

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H: 220 / 270

P: 210 / 220

Oxygen is a colourless, odourless and tasteless oxidising gas. Fire hazard in contact with flammable substances.

Hydrogen is a colourless, odourless and tasteless flammable gas that easily forms explosive mixtures with air. In experiments involving hydrogen, all sources of ignition must be removed beforehand.

Wear safety goggles.

Setup (1/7)

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Connect the two line modules with connection socket, the two gas accumulators and the PEM electrolyser marked in blue as shown in Fig. 1.

Connect both gas storage tanks to the PEM electrolyser using two hoses each.



Fig. 1

Setup (2/7)

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Attach a hose to the free end of each gas cylinder and clamp it with a hose clamp (Fig. 2).

Assemble the circuit for the fuel cell, the motor and the cable components as shown in Fig. 3.

Pay attention to the poles. Connect the positive side of the motor to the positive side of the fuel cell.



Fig. 2

Setup (3/7)

PHYWE

Now connect both components as shown in Fig. 4. Check the poles of the individual components. The poles on the left of the fuel cell, the electrolyser and the motor must be the same as those on the right. If necessary, turn the motor and the fuel cell round.



Fig. 3



Fig. 4

Montaje (4/7)

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Pour about 150 ml of distilled water into your 400 ml beaker. Fill both gas cylinders from the top to the bottom mark (Fig. 5).

Attention: Only use distilled water.



Fig. 5

Fig. 6

Setup (5/7)

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Open the hose clamps so that the water flows downwards into the tank. The free end of the hose should be held slightly upwards to avoid spilling water (Fig. 6).

Re-clamp the hose and connect the free hose ends to the fuel cell (Fig. 7).



Fig. 7

Fig. 8



Setup (6/7)

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The two additional hoses are intended to prevent any leaking water from reaching the contacts.

Insert the tripod rod vertically into the tripod base and attach the double sleeve to the upper end of the tripod rod (Fig. 8).

Attach the halogen lamp to the double socket and connect the lamp to the 12 V output of the switched-off power supply unit (Fig. 9).



Fig. 9

Setup (7/7)

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Connect the solar cell to the cable modules with connection socket according to the polarity on the electrolyser. The red plug is the positive pole and the blue plug is the negative pole (Fig. 10).

Place the solar cell directly under the halogen lamp (Fig. 11).

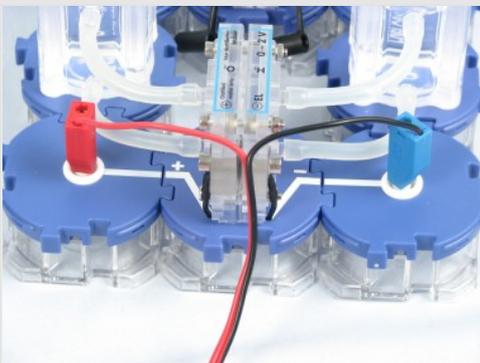


Fig. 10



Fig. 11

Procedure (1/3)

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First note the current fill level of the two gas cylinders under (1).

Switch on the power supply unit and start the stopwatch (Fig. 12). Switch the power supply unit off again after 5 minutes and note the fill level of the two gas cylinders again under (2).

Open the hose clamp on the oxygen side of the fuel cell (see labelling on the fuel cell and the electrolyser).

Measure the time the motor runs when you open the hose clamp on the hydrogen side. Make a note of your observations under (3).



Fig. 12

Procedure (2/3)

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Empty the two gas cylinders as described below and then refill them as described above.

Move the double sleeve together with the halogen lamp to about a third of the height of the stand rod (Fig. 13).

Repeat experiment 1 and note down the observations under (4), (5) and (6) analogue to (1), (2) and (3).



Fig. 13

Procedure (3/3)

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Emptying the gas storage tank:

With the power supply unit switched off, remove the cables and the line modules. Ensure that the hose clamps are closed and grasp one gas cylinder with each hand. The electrolyser is not removed. Lift one of the two gas reservoirs over the beaker and tip the contents out over a corner (Fig. 14).

Proceed in the same way with the second gas cylinder.

Fig. 14



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Report



Observations 1

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How much gas is available in the gas storage facilities?

15 each cm^3

10 each cm^3

5 each cm^3

Observations 2

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How much gas is in the gas storage tanks after 5 minutes?

There are now 9 cm^3 Gas on the oxygen side and 7 cm^3 on the hydrogen side

There are now 14 cm^3 Gas on the oxygen side and 18 cm^3 on the hydrogen side

There are now 18 cm^3 Gas on the oxygen side and 18 cm^3 on the hydrogen side

There are now 7 cm^3 Gas on the oxygen side and 9 cm^3 on the hydrogen side

Observations 3

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How long does the engine run when you open the terminal on the hydrogen side of the fuel cell?

 2:00 minutes 1:30 minutes 1:00 minute

Observations 4

PHYWE

How much gas is available in the gas storage facilities?

 10 each cm³ 15 each cm³ 5 each cm³

Observations 5

PHYWE

How much gas is in the gas storage tanks after 5 minutes the second time?

There are now 14 cm³ Gas on the oxygen side and 8 cm³ on the hydrogen side

There are now 8 cm³ Gas on the oxygen side and 11 cm³ on the hydrogen side

There are now 11 cm³ Gas on the oxygen side and 8 cm³ on the hydrogen side

There are now 22 cm³ Gas on the oxygen side and 22 cm³ on the hydrogen side

Observations 6

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How long will the engine run this time if you loosen the clamp on the hydrogen side of the fuel cell?

3:20 minutes

3:40 minutes

1:30 minutes

4:00 minutes

Evaluation (1/5)

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How much gas was produced in each of the two experiments?

Evaluation (2/5)

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Why is a different amount of gas produced when the distance between the halogen lamp and the solar battery changes?

At a smaller [input], the [input] is greater, so the output of the solar battery is greater and more [input] also means better [input] in the electrolyser. Additional [input] occur if the distance is too great, if the table next to the solar battery is also illuminated.

light intensity

distance

losses

output

gas production

 Check

Evaluation (3/5)

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When the hose clamps are opened, the gas escapes immediately and the water level in the gas cylinders returns to the level at the start of the test.

Why are the engine running times still so different?

Evaluation (4/5)

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Why is it necessary to empty and refill the two gas cylinders between the two tests?

This is necessary so that you have the same [] in test 1 and 2. In question 2, we have already established that the [] of [] or oxygen in the gas storage tanks changes as a result of the experiment. This would result in different [] concentrations, which would make a [] impossible

test conditions

hydrogen

comparison

starting

concentration

 Check

Evaluation (5/5)

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The halogen lamp serves as a substitute for the sun in this experiment.

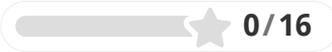
What are the advantages and disadvantages of the sun as an energy source?

Evaluation - additional task

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Why not simply use a rechargeable battery instead of taking the diversions via gas production and the fuel cell?

| Slide | Score / Total |
|-----------------------------------|---------------|
| Slide 20: Observations 1 | 0/1 |
| Slide 21: Observations 2 | 0/1 |
| Slide 22: Observations 3 | 0/1 |
| Slide 23: Observations 4 | 0/1 |
| Slide 24: Observations 5 | 0/1 |
| Slide 25: Observations 6 | 0/1 |
| Slide 27: Behaviour after removal | 0/5 |
| Slide 29: Reason for emptying | 0/5 |

Total score  0/16 Show solutions Repeat Export text