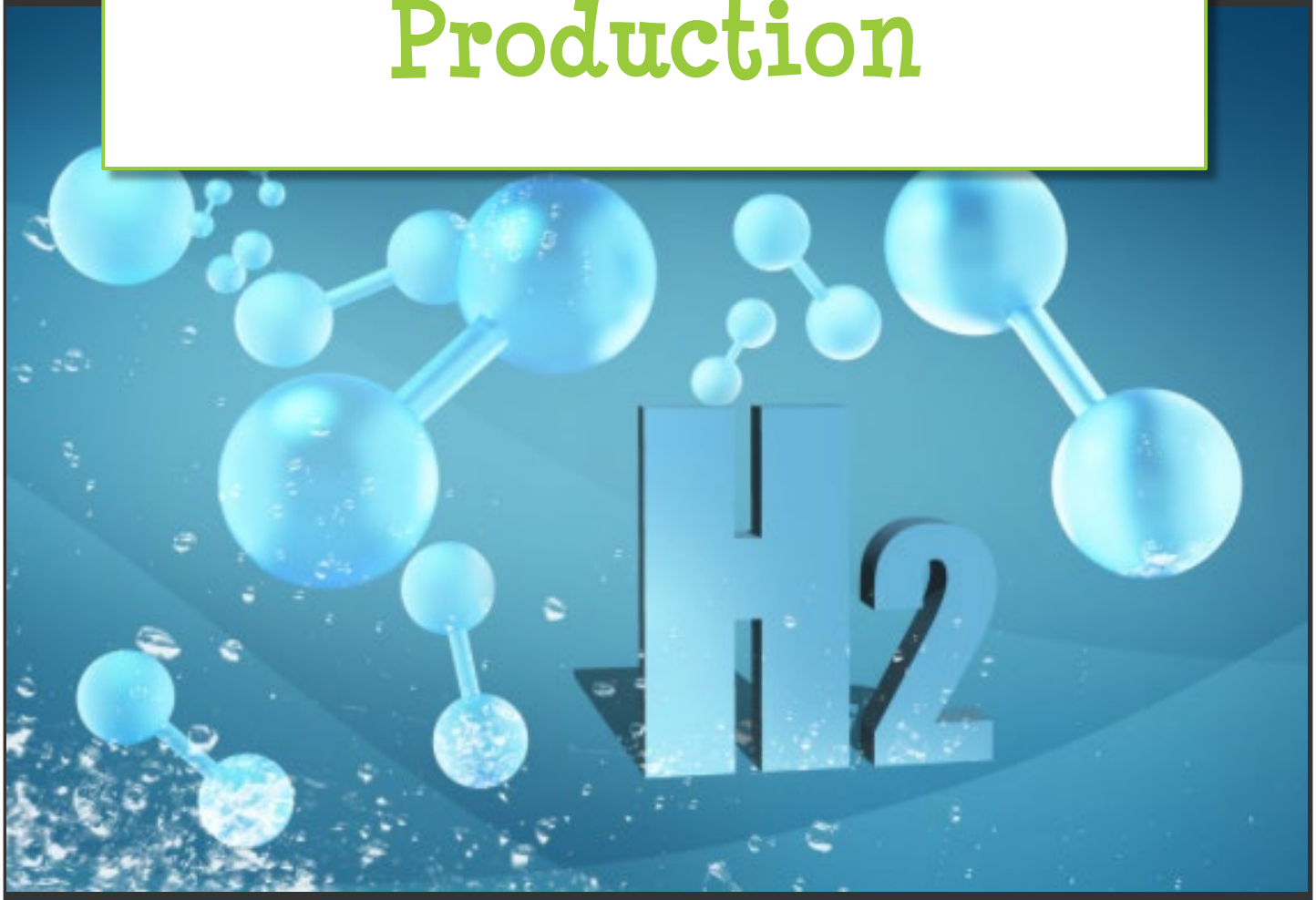
Hydrogen Production



the human energy company™ Chevron

AUSTRALIAN EARTH SCIENCE EDUCATION

Hydrogen Production – Teacher Resource

Powering Careers in Energy Link:

Unit 2: Demonstrate an understanding of the importance of science in LNG operations

Background Information:

Hydrogen is the most abundant element in the universe. It is present in many molecules but rarely found in its pure form because it has a very low density and escapes Earth's atmosphere.

Hydrogen production is an important first step in creating many industrial chemicals, with 50% used in the manufacture of ammonia. Hydrogen is also a promising form of energy storage, as it can be used to generate electricity with water as a waste gas.

Aim

To model the production of hydrogen from methane, in the steam reforming process, and from water, in electrolysis.

Materials

Per small group

- Molecular modelling kit, LEGO bricks, or lollies with three colours to represent carbon, hydrogen, and oxygen.
- Molecule photos

Safety Notes

If using lolly models and eating these, appropriate hygiene must be maintained. Students with allergies should not handle potential triggering foods.

Method

1. Create one methane molecule (CH_4) and at least 4 water molecules (H_2O)
2. Steam reforming of methane:
    - Step 1: Use one methane molecule and as many waters as necessary to create a carbon monoxide (CO) molecule and hydrogen (H_2) molecules. Complete the Step 1 equation with numbers.
    - Step 2: Use the carbon monoxide from Step 1 and as many waters as necessary to create a carbon dioxide (CO_2) molecule and hydrogen molecule(s). Complete the Step 2 equation with numbers.

3. Electrolysis of water:
    - Use the smallest possible number of water molecules to create oxygen (O_2) and hydrogen molecules. Complete the electrolysis equation with numbers.

Results

Steam reforming of methane balanced equation:

Step 1: methane (CH_4) + *1* water (H_2O) → carbon monoxide (CO) + *3* hydrogen (H_2)

Steam-methane reforming reaction

Step 2: carbon monoxide (CO) + *1* water (H_2O) → carbon dioxide (CO_2) + *1* hydrogen (H_2)

Water-gas shift reaction

Electrolysis of water balanced equation:

2 water (H_2O) → *1* oxygen (O_2) + *2* hydrogen (H_2)

Discussion

1. How many hydrogen molecules are formed for each carbon molecule in the steam reforming process?

   Four hydrogen molecules are formed.

2. Both methods of hydrogen production require energy (heat or electricity). Where did the energy to break and reform bonds come from in your model?

   The energy in the model came from students who rearranged the molecules (muscles convert chemical potential energy to kinetic energy).

Evaluation:

1. Hydrogen is commonly used for industrial chemical manufacturing but can be used to power vehicles or create electricity. What factors would you need to consider when choosing a process to generate hydrogen?

   You would need to consider the availability of water (both) and methane (steam reforming). The cost of the energy used in the process is a major factor. Finally, you should consider the impact of the waste products (CO_2 and O_2) on the environment. (For teachers: steam reforming is currently much cheaper, more efficient and the most common methane production method.)

Further Information:

The US Office of Energy Efficiency and Renewable Energy has more information about the steam-methane reforming process on their webpage, Hydrogen Production: Natural Gas Reforming and on the electrolysis of water on their webpage, Hydrogen Production: Electrolysis

Worksheet: Hydrogen Production

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    - Use the smallest possible number of water molecules to create oxygen (O_2) and hydrogen molecules. Complete the electrolysis equation with numbers.

Results

Steam reforming of methane balanced equation:

Step 1: methane (CH_4) + ___ water (H_2O) → carbon monoxide (CO) + _____ hydrogen (H_2)

Step 2: carbon monoxide (CO) + ___ water (H_2O) → carbon dioxide (CO_2) + _____ hydrogen (H_2)

Electrolysis of water balanced equation:

_____water (H_2O) → _____oxygen (O_2) + _____ hydrogen (H_2)

Discussion

1. How many hydrogen molecules are formed for each carbon molecule in the steam reforming process?

2. Both methods of hydrogen production require energy (heat or electricity). Where did the energy to break and reform bonds come from in your model?

Evaluation

1. Hydrogen is commonly used for industrial chemical manufacturing but can be used to power vehicles or create electricity. What factors would you need to consider when choosing a process to generate hydrogen?

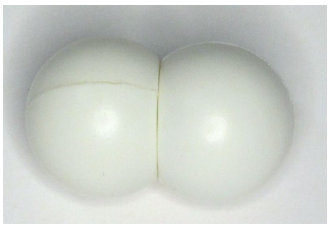
Molecule Photos

Water (H_2O)

Methane (CH_4)

Carbon monoxide (CO)

Carbon dioxide (CO_2)



Hydrogen (H_2)

Key

White = Hydrogen

Red = Oxygen

Black = Carbon