Gay-Lussac's Law of Gaseous Combustion (Item No.: P3022100)

Curricular Relevance

Area of Expertise: Chemistry
Education Level: University
Topic: Physical Chemistry
Subtopic: Gas Laws
Experiment: Gay-Lussac's Law of Gaseous Combustion

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	1 Hour	1 Hour	2 Students

Additional Requirements:

- Transparent plastic bag (airtight bag)

Experiment Variations:

Keywords:

Hydrogen/oxygen reaction

Task and equipment

Introduction

Principle:
In this experiment, the volume relationship in the hydrogen/oxygen reaction will be examined using a plunger eudiometer.

Safety warnings:

- Hydrogen is a colourless flammable gas that forms explosive mixtures with air and oxygen.
- It is necessary that you follow the directions for the usage of the plunger eudiometer carefully when working with it. It should be completely clean, so that the plunger slides easily, without any possibility of locking (danger of shattering!).
- Protective clothing (protective glasses, etc.) must be worn.
- The gas mixture for hydrogen/oxygen reactions in a cold eudiometer must always be chosen in a way that one of the gases is present in excess. The residual gas must act as a buffer to the forward darting plunger to prevent it from hitting hard against the front of the eudiometer. That way the risk of breaking the glass is prevented. It is recommended to work with an excess of oxygen.
- Alternatively, a little bit of air can be first introduced into the eudiometer, so that this brakes the plunger movement. In this case, a stoichiometric gas mixture can be used.
- Stoichiometric gas mixtures can also be used with gas reactions that produce gaseous products (e.g. for carbon monoxide/oxygen reactions), because then the reaction product acts as a buffer.
- Before ignition, place the eudiometer in a plastic bag with a wall thickness big enough.
- That does not only provide some protection against splinters, but also gives the rubber cap an additional hold against the pressure of explosion, so that it is not blown off of the tube.

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Safety instructions

Safety warnings:

- Hydrogen is a colourless flammable gas that forms explosive mixtures with air and oxygen.

Oxygen
H270: May cause or intensify fire; oxidizer
H280: Contains gas under pressure; may explode if heated
P220: Keep/Store away from clothing/.../combustible materials.
P403: Store in a well ventilated place.

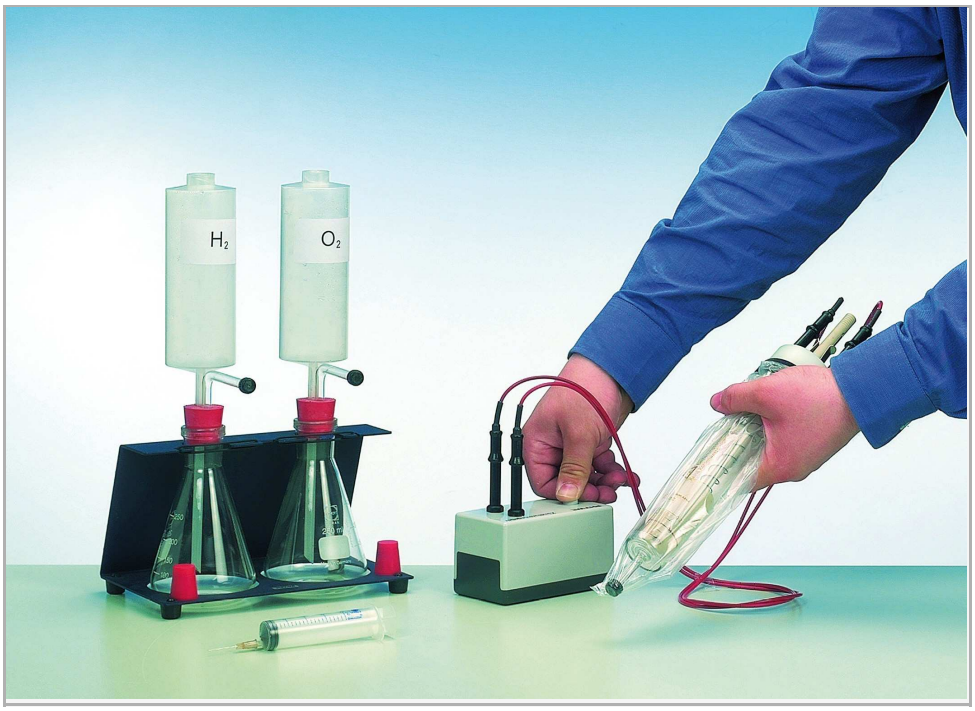
Hydrogen
H220: Extremely flammable gas.
H280: Contains gas under pressure; may explode if heated.
P210: Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P377: Leaking gas fire – do not extinguish unless leak can be stopped safely.

Equipment

Position No.	Material	Order No.	Quantity
1	Plunger eudiometer	02611-00	1
2	Ignition spark generator	11155-00	1
3	Connecting cord, 30 kV, 1000 mm	07367-00	2
4	Gas bar	40466-00	1
5	Syringe 20ml, Luer, 10 pcs	02591-03	1
6	Cannula 0,45x13 mm, Luer, 20 pcs	02598-04	1
7	Rubber caps, pack of 20	02615-03	1
8	Steel cylinder oxygen, 2 l, filled	41778-00	1
9	Steel cylinder hydrogen, 2 l, full	41775-00	1
10	Reducing valve f.oxygen	33482-00	1
11	Reducing valve for hydrogen	33484-00	1
12	Table stand for 2 l steel cylinders	41774-00	2
13	Wrench for steel cylinders	40322-00	1
14	Silicone tubing i.d. 7mm, 1 m	39296-00	2
15	Hose clip, diam. 8-16 mm, 1 pc.	40996-02	2
16	Lab protecting glasses with UV filter	39315-00	1

Task

In this experiment, the volume relationship in the hydrogen/oxygen reaction will be examined using a plunger eudiometer.



Set-up and procedure

Safety warnings:

- Hydrogen is a colourless flammable gas that forms explosive mixtures with air and oxygen.

In this experiment, the volume relationship in the hydrogen/oxygen reaction will be examined using a plunger eudiometer. Therefore, provide the two small gasometers of the gas bar with hydrogen and oxygen, as shown in Figure 1.

Prepare the gas bar by filling water through the cylindrical funnels into the Erlenmeyer flasks of the small gasometers, until the flasks and the rightangled glass tubes are filled as bubble-free as possible. Excess water runs out of the glass tubes, so that the correct amount of water adjusts itself automatically.
Now connect the glass tubes to the gas supply (steel cylinder or pressure container), one to hydrogen, the other to oxygen. Strat a slow flow of gas. The gases push water out of the flasks up into cylindrical funnels, and are themselves collected in the flasks. When the flasks are full, close the open ends of the glass tubes with rubber caps.

Small gas portions in volumes of a few ml can be easily removed from the gasometers through the rubber caps using an injection syringe.

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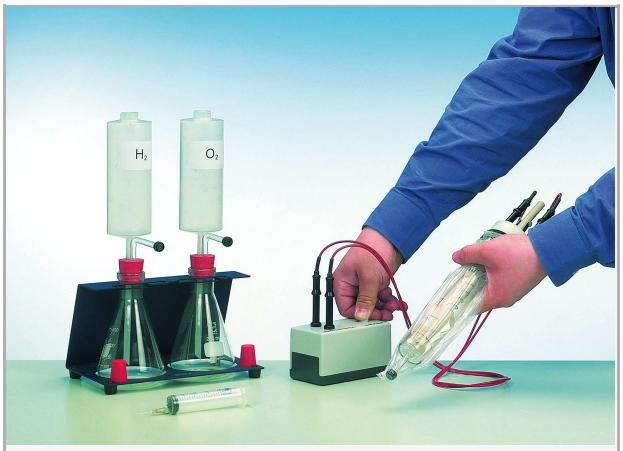

Fig. 1

After having checked if the explosion eudiometer is in a flawless condition according to its operating instructions, connect the two electrical contacts to the ignition spark generator (Fig. 2).

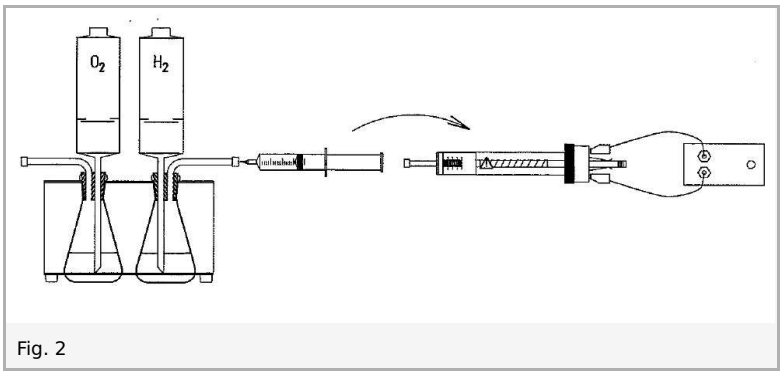

Fig. 2

Position the plunger of the eudiometer to the zero mark on the scale, and close it with a tight fitting rubber cap. Using a 20 ml injection syringe and a fine cannula (d = 0.45 mm, l = 13 mm), pierce the rubber cap of the oxygen gasometer with the cannula and extract 10 ml of oxygen, then similarly extract 4 ml of hydrogen from the hydrogen gasometer. The syringe now contains a reaction mixture consisting of 10 parts by volume of oxygen and 4 parts by volume of hydrogen. Inject this mixture into the eudiometer. The scale of the eudiometer must now show a volume of 14 ml.
As a safety precaution, pack the eudiometer in a thick transparent plastic bag (e.g. and airtight bag). Hold the eudiometer horizontally with one hand, gripping the bag and eudiometer around the area of the black screw cap. With the other hand, operate the ignition spark generator.
Important! The plunger rod must have space to freely shoot out of the back of the eudiometer.

Results and evaluation

A small explosion (energy content approximately 52 Joules) first forces the plunger back for about 10 cm, but then the plunger is immediately re-drawn into the cylinder. There is a residual gas volume in the eudiometer of about 8 ml, and the walls of the reaction chamber are misted up with drops of water.

1. Result

The experiment shows that 4 ml of hydrogen require 2 ml of oxygen to be burnt to water, completely.

Continuation
To check the result obtained in the first experiment, inject another 4 ml of hydrogen to the 8 ml of residual gas and ignite it as above. The eudiometer now contains a residual gas (oxygen) volume of 6 ml.

2. Result

Hydrogen and oxygen always react with each other in a volume ratio of 2:1.
Further tests have shown that all gases always react with each other in a certain volume ratio. This phenomenon therefore was called “the law of volumes” for gases (Gay-Lussac, 1808). The explanation for this rule was given by Avogadro's work.
Gay-Lussac's Law of Gaseous Combustion implies that gases always react with each other in a certain volume ratio.

Note
When hydrogen reacts with oxygen in the plunger eudiometer, only a quite soft noise is audible. To demonstrate that the hydrogen and oxygen mixture bangs, as the German name for it (Knallgas) implies, inject 8 ml of hydrogen and 4 ml of oxygen into the eudiometer as above, remove the rubber cap and immediately ignite the mixture. As the reaction space is no longer sealed off from the surroundings, the noise can be clearly heard.

Take care! Here again, there is a risk of splintering. Perform the experiment behind safety glass, wear protective glasses and suitable protective clothing.

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