Condensation of gases through an increase of pressure and through cooling

In this experiment the students learn about pressure increase and cooling as methods for transforming a gas into a liquid.

Chemistry	General Chemistry	States of matter, dissolution (kinetic particle theory)
Chemistry	Physical chemistry	Phaseequilibrium

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

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General information

Application

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Cooking with gas

Liquified gases are relevant for a broad spectrum of applications.

From the liquid propane gas (LPG) used in cars or for cooking at home to liquified oxygen and hydrogen in the fuel tanks of a rocket.

In this experiment we want to investigate how to liquify butane to understand the necessary conditions and from there possible methods to use for gas liquification.

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Other information (1/2)

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Prior knowledge

The students should be aware that there is a connection between the phase transition from gaseous to liquid and the pressure and temperature of the medium.

Scientific principle

Gases are condensing when they are cooled and at high pressure. In this experiment butane is condensed by cooling it to ca. -15 °C.

In the second part of the experiment butane is condensed by compressing it.

Other information (2/2)

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Learning objective

In this experiment the students learn about pressure increase and cooling as methods for transforming a gas into a liquid.

Tasks

1. Condense butane by cooling it under its boiling point of 0.4 °C.

2. Condense butane at high pressure.

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Safety instructions

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Be careful when working with liquefied gas! When combined with air, explosive mixtures result.

When burning it off, ensure that the apparatus has been flushed in an air-free manner. Otherwise, there is a risk of blowback and explosion.

Avoid any pressure build-up in closed apparatuses!

For this experiment the general instructions for safe experimentation in science lessons apply.

For H- and P-phrases please consult the safety data sheet of the respective chemical.

Theory

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The experiments described herein are intended to consolidate the concept of the composition of substances based on particles. The three states of aggregation of a substance in the context of thermal mo-tion can be explained only by way of the particle theory.

- Increasing the temperature leads to stronger thermal motion of the particles, increasing the pressure in a fixed volume.
- Lowering the temprature decreases the thermal motion of the particles and with it the pressure in a fixed volume.
- Increasing the pressure by decreasing the volume pushes the particles closer together, forcing them to change into a phase with higher density at a certain point.
- Lowering the pressure by increasing the volume gives the particles more space to move and allows them to enter a phase with lower density.

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Equipment

Position	Material	Item No.	Quantity
1	Support base DEMO	02007-55	1
2	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
3	Right angle boss-head clamp	37697-00	4
4	Universal clamp	37715-01	4
5	Lab jack, 160 x 130 mm	02074-00	1
6	Gas liquefier	08173-00	1
7	Butane burner, Labogaz 206 type	32178-00	1
8	Butane cartridge C206, without valve, 190 g	47535-01	1
9	Gasometer 1000 ml	40461-00	1
10	Dewar vessel,500 ml	33006-00	1
11	Thermometer,-100....+30 C	38151-00	1
12	Test tube GL25/8, w.hose connec.	36330-15	2
13	Glass tubes,right-angled, 10	36701-59	1
14	Glass tube,right-angled w.tip,10	36701-53	1
15	Stopcock,3-way,t-shaped, glass	36731-00	1
16	Rubber stopper, d = 22/17 mm, 1 hole	39255-01	2
17	Rubber tubing, i.d. 6 mm	39282-00	2
18	Commercial weight, 1000 g	44096-70	1
19	Pinchcock, width 15 mm	43631-15	1
20	Glass wool 10 g	31773-03	1
21	Sodium chloride, 500 g	30155-50	1

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Additional equipment

Position	Material	Quantity
1	Ice	1

Setup and procedure

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Procedure (1/4) - Liquifiying increase of pressure

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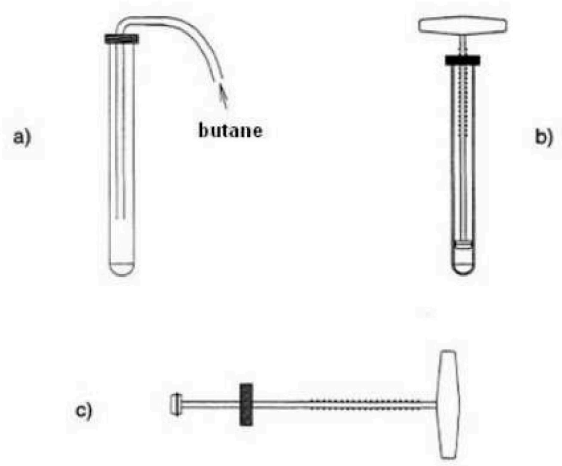

Figure 1

- Guide some butane gas from a butane source (butane burner, butane soldering torch, pressurised dispenser) as shown in Fig. 1a) via a hose and a glass tube into the cylinder of the gas liquifier until it is completely full (butane is heavier than air).
- Then, insert the piston (Fig. 1c) into the cylinder, attach and tighten the union nut, push the piston deep into the cylinder and lock it in place by rotating it slightly (Fig. 1b).

Procedure (2/4) - Liquifiying cooling

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- Set the experiment up as shown in Figure 2. The Dewar vessel holds a calorimeter insert. Via connector 2 (see the additional illustration), this calorimeter insert is connected to a three-way stopcock to which a butane gas source and a gasometer are connected. Connector 1 holds a bubble counter with a right-angled glass tube.
- Fill some quartz glass wool into the glass tube as blowback protection. Opening 3 of the calorimeter insert is sealed tightly with a rubber stopper.

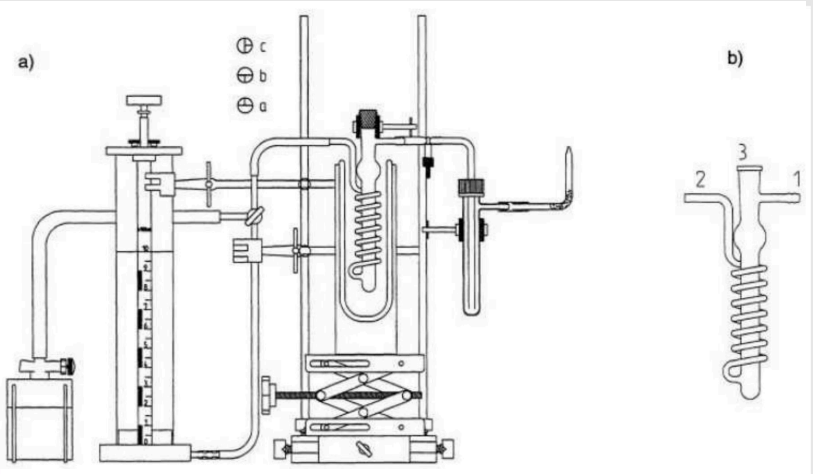

Figure 2

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Procedure (3/4) - Liquifiying cooling

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- The hose connection between the calorimeter insert and the bubble counter is equipped with a pinchcock.
- Keep some crushed ice and common table salt ready
- In order to liquify the gas, let some butane gas flow into the calorimeter insert and bubble counter via the three-way stopcock (position a) until the air has been completely pushed out of these equipment parts.
- Then, set the three-way stopcock to position b and close the pinchcock upstream of the bubble counter.

Experimental setup

Procedure (4/4) - Liquifiying cooling

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- Let 500 or 1,000 ml of butane flow into the gasometer.
- Then, stop the gas flow, set the stopcock to position c.
- Fill a mixture of ice and salt into the Dewar vessel.

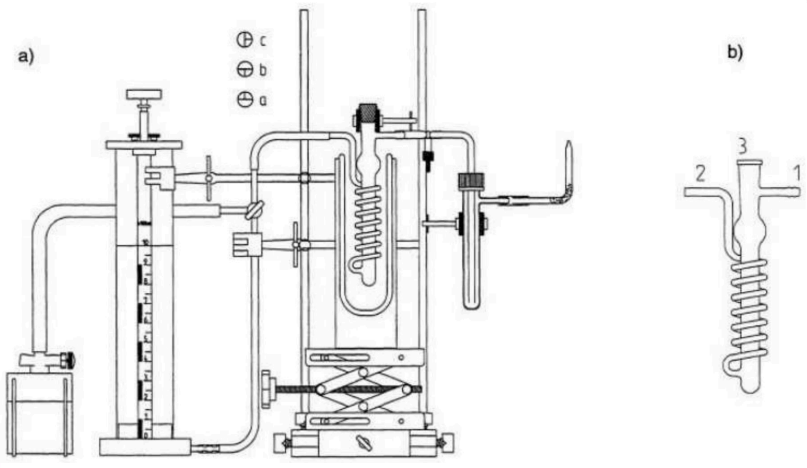

Figure 2

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Evaluation

Evaluation (1/4)

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Notes

If the butane in the gasometer is not required for any subsequent experiments, place a weight of 500 g on top of the gasometer and let the gas burn slowly at the outlet nozzle downstream of the bubble counter. The boiling point of butane is at -0.4 °C.

The experiments described herein are intended to consolidate the concept of the composition of sub-stances based on particles. The three states of aggregation of a substance in the context of thermal mo-tion can be explained only by way of the particle theory. During these experiments, the students learn about pressure increase and cooling as methods for transforming a gas into a liquid.

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Evaluation (2/4)

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LIQUIFYING GAS THROUGH A PRESSURE INCREASE

Observation:

The butane gas _____ due to the pressure that is applied by the _____ . When the piston is unlocked, the butane _____ slowly, thereby pushing the piston back into its initial position.

Result:

Gas can be liquified through _____ .

piston
evaporates
pressure
liquifies

Check

Evaluation (3/4)

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LIQUIFYING GAS THROUGH COOLING

Observation: The temperature in the Dewar vessel falls to a value below _____ . The piston in the gasometer moves relatively quickly _____ until it reaches the bottom. When the insert is then lifted out of the Dewar vessel, a crystal-clear _____ can be seen. When the insert heats up in the air the liquid _____ . The resulting _____ fills the gasometer once again until the initial position is reached.

evaporates
liquid
downwards
gas
-10 °C

Check

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Evaluation (4/4)

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What statement can you make about butane after completing experiment 2?

- [ ] Butane can be converted into a solid form by cooling.
- [ ] Butane can be easily liquified through cooling.
- [ ] Butane can be easily liquified through cooling.
- [ ] The state of butane does not change due to cooling, as butane is a noble gas and therefore does not react.

Überprüfen

Slide	Score / Total
Slide 16: Liquifying gas - pressure increase	0/4
Slide 17: Liquifying gas - through cooling	0/5
Slide 18: Butane: summary	0/2

Total Score 0 / 11

Show solutions Retry

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