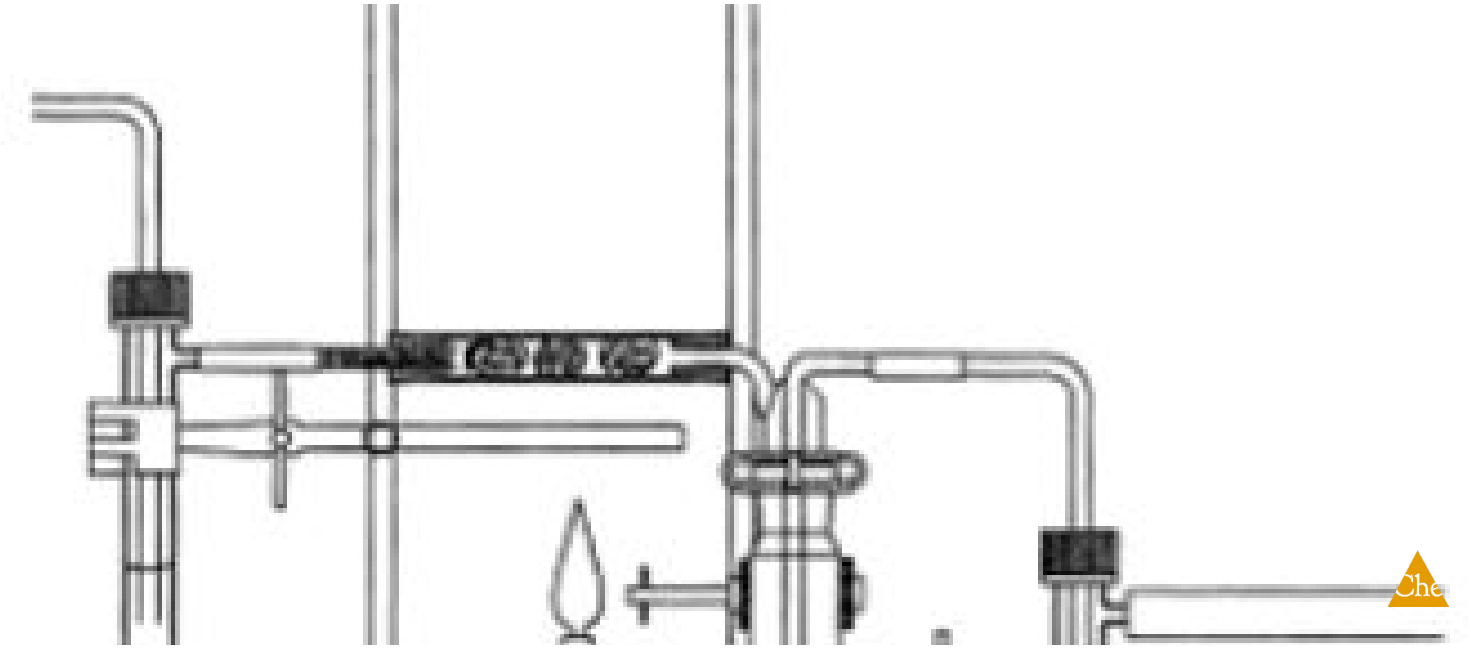
Combustion of ammonia to produce nitrogen dioxide - Ostwald process



In the presence of a suitable catalyst and while giving off heat, ammonia-air mixtures burn and form nitrogen monoxide and water. Nitrogen monoxide reacts immediately with the excess oxygen, thereby forming nitrogen dioxide.

Chemistry > Industrial Chemistry > industrial synthesis

Difficulty level	Group size	Preparation time	Execution time
hard	2	10 minutes	20 minutes

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General information

Application

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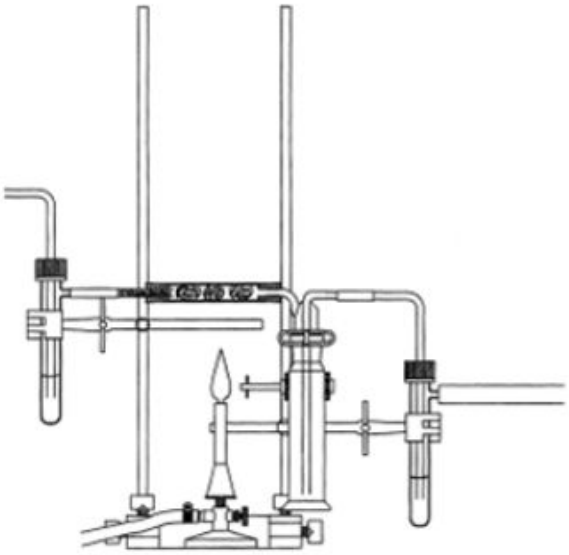

Nitrogen dioxide is a reddish- brown gas with a pungent, acrid odor.

It is used as an intermediate in the manufacturing of nitric acid, as a nitrating agent in manufacturing of chemical explosives, as a polymerization inhibitor for acrylates, as a flour bleaching agent and as a room temperature sterilization agent.

Nitrogen dioxide is also used as an oxidizer in rocket fuel, for example in red fuming nitric acid.

It was used in the Titan rockets, to launch Project Gemini, in the maneuvering thrusters of the Space Shuttle, and in unmanned space probes sent to various planets.

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Other information (1/2)

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Prior knowledge

In the presence of a suitable catalyst and while giving off heat, ammonia- air mixtures burn and form nitrogen monoxide and water. Nitrogen monoxide reacts immediately with the excess oxygen, thereby forming nitrogen dioxide.

Scientific principle

At higher temperatures, nitrogen monoxide is decomposed into nitrogen and oxygen. This is why the contact with the catalyst must be very brief. In the presence of water and oxygen, nitrogen dioxide forms nitric acid. On a large industrial scale, the combustion of ammonia with atmospheric oxygen is performed under contact with platinum.

Other information (2/2)

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Learning objective

The objective of this experiment is to observe the combustion of ammonia in the presence of a catalyst. The students should prove that the resulting compound is nitrogen dioxide.

Tasks

- The students should burn Ammonia-air mixture in the presence of a catalyst.
- They should observe the reactions that take place.
- The observations have to be noticed in the Protocol.

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Safety instructions

Ammonia-air mixtures with an ammonia content of 15.5 to 27% by volume are explosive.

This is why the combustion tube must be filled with quartz glass wool and the 8 mm tube with iron wool.

Towards the student side protection must be provided in the form of a transparent safety shield.

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

Nitrogen dioxide typically arises via the oxidation of nitric oxide by oxygen in air.

$$2NO + O_2 -> 2NO_2$$

Nitrogen dioxide is formed in most combustion processes using air as the oxidant. At elevated temperatures nitrogen combines with oxygen to form nitric oxide:

$$O_2 + N_2 -> NO$$

The compound can also be prepaed in the laboratory in a two step procedure. The procedure consists in the dehydration of nitric acid which produces dinitrogen pentoxide.

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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	3
4	Universal clamp	37715-01	3
5	Test tube GL25/8, w.hose connec.	36330-15	2
6	Combustion tube, l 120mm,	37029-01	1
7	Glass tube, straight, l=80 mm, 10/pkg.	36701-65	1
8	Glass tubes,right-angled, 10	36701-59	1
9	Gas washing bottle, 100 ml	36691-00	1
10	Clamp for ground joint, plastic, IGJ29	43615-00	1
11	Teflon sleeve IGJ 29, 10 pcs	43617-00	1
12	Rubber stopper, d = 22/17 mm, 1 hole	39255-01	2
13	Teclu burner, DIN, natural gas	32171-05	1
14	Safety gas tubing, DVGW, sold by metre	39281-10	1
15	Lighter f.natural/liquified gases	38874-00	1
16	Hose clip f.12-20 diameter tube	40995-00	2
17	Water jet pump, plastic	02728-00	1
18	Rubber tubing,vacuum,i.d.6mm	39286-00	1
19	Rubber tubing, i.d. 6 mm	39282-00	1
20	Funnel, glass, top dia. 50 mm	34457-00	1
21	Beaker, Borosilicate, tall form, 150 ml	46032-00	1
22	Glass rod,boro 3.3,l=300mm, d=7mm	40485-05	1
23	Tweezers,straight,blunt, 200 mm	40955-00	1
24	Wash bottle, plastic, 500 ml	33931-00	1
25	Pasteur pipettes, 250 pcs	36590-00	1
26	Rubber caps, 10 pcs	39275-03	1
27	Glass wool 10 g	31773-03	1
28	Iron wool 200 g	31999-20	1
29	Litmus, powder 25 g	31517-04	1
30	Ammonia solution, 25% 1000 ml	30933-70	1
31	Glycerol, 250 ml	30084-25	1
32	Water, distilled 5 l	31246-81	1
33	Bead catalyst, 50g	31763-03	1

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Setup and procedure

Procedure (1/3)

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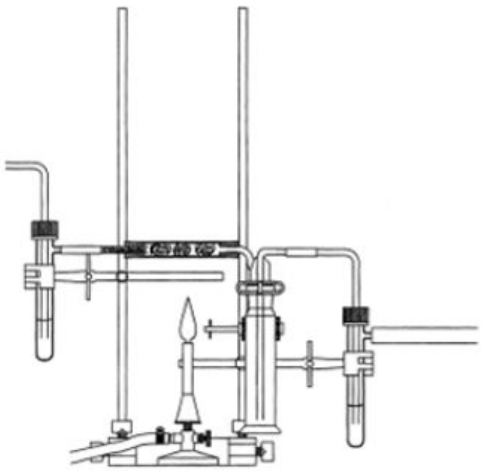

Experimental setup

Fill the test tube with a hose connector on the left approximately 5 cm high with an ammonia solution of medium concentration.

Push a right-angled glass through the hole in the screw cap seal.

Ensure that the long leg plunges into the ammonia solution by not more than 1 cm.

Attach the test tube to the support system.

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Procedure (2/3)

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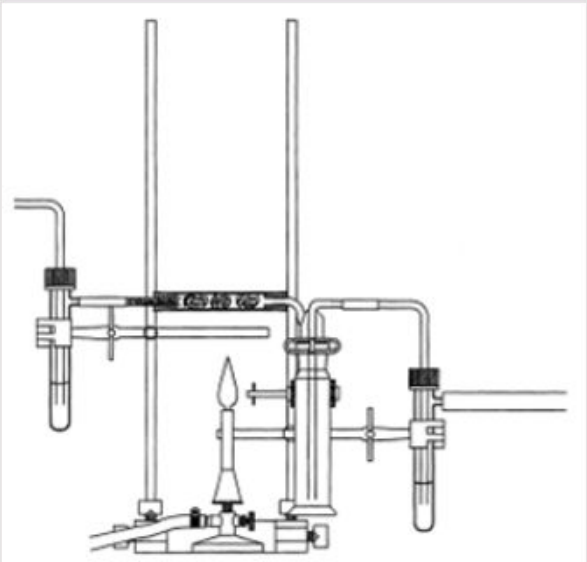

Connect an approximately 8 mm long glass tube to the hose connector of the test tube.

This glass tube must be completely filled with iron wool over its entire length as blowback protection.

Connect this tube via a rubber stopper to the short combustiontube that contains quartz glass wool and some catalyst beads.

When filling this tube, start by filling some quartz glass wool into one half of the tube.

Then, use the tweezers to add a layer of catalyst beads of approximately 2 to 3 mm before filling the second half of the combustion tube with quartz glass wool.

Procedure (3/3)

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Connect an empty gas wash bottle to the reaction tube.

Use a short piece of rubber tubing to connect a test tube with a hose connector to the gas wash bottle.

Fill the test tube up to one third with distilled water to which some drops of litmus solution were added.

Connect this test tube to a water jet pump via a vacuum hose.

Heat the small strip of catalyst beads for a few seconds with the burner flame.

Switch the water jet pump on and adjust it so that a moderate air flow flows through the apparatus.

When the catalyst starts to glow, remove the burner and adjust the air flow so that the catalyst glows only very faintly.

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Evaluation

Evaluation (1/3)

- A red- brown gas collects in the wash bottle.
- In the test tube with a hose connector, this gas causes the litmus solution to turn red.
- If a white mist forms first, the ammonia content of the gas mixture is too high. The resulting substances are ammonia nitrate and ammonia nitrite.
- When the ammonia concentration decreases, the mist disappears.

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Evaluation (2/3)

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Complete the reactions that take place during this experiment.

$4NH_3 + 5O_2 - >$ ____

$2NO + O_2 - >$ ____

$4NO_2 + 2H_2O + O_2 - >$ ____

$4NO + 6H_2O$

$2NO_2$

$4HNO_3$

Check

Evaluation (3/3)

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In the presence of a suitable catalyst and while giving off heat, ammonia-air mixtures burn and form

only nitrogen monoxide

Nitrogen monoxide and water

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Slide	Score/Total
Slide 14: Reaction scheme	0/3
Slide 15: Summary of the experiment	0/4

Total Score 0/7

Show solutions Retry

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