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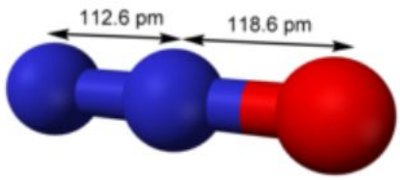
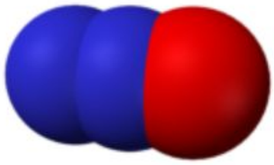
Nitrous oxide

Nitrous oxide, commonly known as **laughing gas** or **nitrous**,[2] is a chemical compound, an oxide of nitrogen with the formula N_2O. At room temperature, it is a colourless non-flammable gas, with a slight metallic scent and taste. At elevated temperatures, nitrous oxide is a powerful oxidizer similar to molecular oxygen. It is soluble in water.

Nitrous oxide





Names

IUPAC name

Dinitrogen monoxide

Other names

Laughing gas, sweet air, protoxide of nitrogen, hyponitrous oxide

Identifiers

CAS Number	10024-97-2 ✓
3D model (JSmol)	Interactive image

Properties	
Chemical formula	N_2O
Molar mass	44.013 g/mol
Appearance	colourless gas

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Density	1.977 g/L (gas)
Melting point	−90.86 °C (−131.55 °F; 182.29 K)
Boiling point	−88.48 °C (−127.26 °F; 184.67 K)
Solubility in water	1.5 g/L (15 °C)
Solubility	soluble in alcohol, ether, sulfuric acid
log *P*	0.35
Vapor pressure	5150 kPa (20 °C)
Magnetic susceptibility (χ)	$-18.9 \cdot 10^{-6}$ cm^3/mol
Refractive index (n_D)	1.000516 (0 °C, 101.325 kPa)

Properties and reactions

Nitrous oxide is a colourless, non-toxic gas with a faint, sweet odour.

Nitrous oxide supports combustion by releasing the dipolar bonded oxygen radical, and can thus relight a glowing splint.

N_2O is inert at room temperature and has few reactions. At elevated temperatures, its reactivity increases. For example, nitrous oxide reacts with $NaNH_2$ at 460 K (187 °C) to give NaN_3:

$$2\,NaNH_2 + N_2O \rightarrow NaN_3 + NaOH + NH_3$$

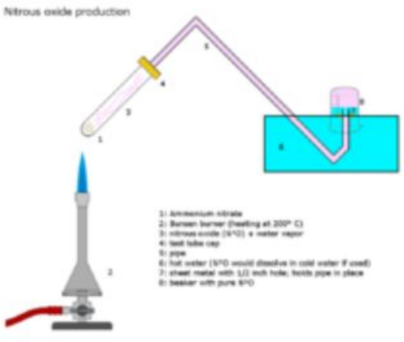
The above reaction is the route adopted by the commercial chemical industry to

Jerome Harris in Boston and Charles E. Barney of Chicago.[89][90]

Production

Reviewing various methods of producing nitrous oxide is published.[91]

Industrial methods



Nitrous oxide production

Nitrous oxide is prepared on an industrial scale by careful heating of ammonium nitrate[91] at about 250 C, which decomposes into nitrous oxide and water vapour.[92]

$$NH_4NO_3 \rightarrow 2\,H_2O + N_2O$$

The addition of various phosphate salts favours formation of a purer gas at slightly lower temperatures. This reaction may be difficult to control, resulting in detonation.[93]

Laboratory methods

The decomposition of ammonium nitrate is also a common laboratory method for preparing the gas. Equivalently, it can be obtained by heating a mixture of sodium nitrate and ammonium sulfate:[94]

$$2\ NaNO_3 + (NH_4)_2SO_4 \rightarrow Na_2SO_4 + 2\ N_2O + 4\ H_2O.$$

Another method involves the reaction of urea, nitric acid and sulfuric acid:[95]

$$2\ (NH_2)_2CO + 2\ HNO_3 + H_2SO_4 \rightarrow 2\ N_2O + 2\ CO_2 + (NH_4)_2SO_4 + 2H_2O.$$

Direct oxidation of ammonia with a manganese dioxide-bismuth oxide catalyst has been reported:[96] cf. Ostwald process.

$$2\ NH_3 + 2\ O_2 \rightarrow N_2O + 3\ H_2O$$

Hydroxylammonium chloride reacts with sodium nitrite to give nitrous oxide. If the nitrite is added to the hydroxylamine solution, the only remaining by-product is salt water. If the hydroxylamine solution is added to the nitrite solution (nitrite is in excess), however, then toxic higher oxides of nitrogen also are formed:

$$NH_3OHCl + NaNO_2 \rightarrow N_2O + NaCl + 2\ H_2O$$

Treating HNO_3 with $SnCl_2$ and HCl also has been demonstrated:

$$2\ HNO_3 + 8\ HCl + 4\ SnCl_2 \rightarrow 5\ H_2O + 4\ SnCl_4 + N_2O$$

Hyponitrous acid decomposes to N_2O and water with a half-life of 16 days at 25 °C at pH 1–3.[97]

$$H_2N_2O_2 \rightarrow H_2O + N_2O$$

Atmospheric occurrence

Nitrous oxide N_2O

N_2O is a stable, relatively unreactive colourless gas. It is prepared by careful thermal decomposition of molten ammonium nitrate at about 280 °C. If heated strongly it explodes. N_2O can also be made by heating a solution of NH_4NO_3 acidified with HCl.

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

N_2O is a neutral oxide and does not form hyponitrous acid $H_2N_2O_2$ with water nor hyponitrites with alkali. It is important in the preparation of sodium azide, and hence also of the other azides:

$$N_2O + 2NaNH_2 \rightarrow NaN_3 + NH_3 + NaOH$$

The largest use of N_2O is as a propellant for whipped ice-cream. Because it has no taste, and is non-toxic, it meets the strict food and health regulations.

N_2O is used as an anaesthetic, particularly by dentists. It is sometimes called 'laughing gas', because small amounts cause euphoria. It requires a partial pressure of 760 mm Hg of N_2O to anaesthetize a patient completely. Thus if dioxygen is also supplied, the patient may not be completely unconscious. If deprived of dioxygen for long, the patient will die. Plainly N_2O is unsuitable for long operations. Usually N_2O is administered to put the patient 'to sleep', and O_2 to make him recover consciousness.

The molecule is linear as would be expected for a triatomic molecule with 16 outer shell electrons (see also N_3^- and CO_2). However, CO_2 is symmetrical (O—C—O), whereas in N_2O the orbital energies favour the formation of the asymmetrical molecule N—N—O rather then the symmetrical molecule N—O—N. The bond lengths are short, and the bond orders have been calculated as N—N 2.73 and N—O 1.61.

$$N \overset{1.126\ \text{Å}}{\text{———}} N \overset{1.186\ \text{Å}}{\text{———}} O$$

Nitrous oxide

Uses

1. as an oxidiser in a rocket motor.
2. In internal combustion engine.
3. Uses as a food additive.
4. used in dentistry and surgery.