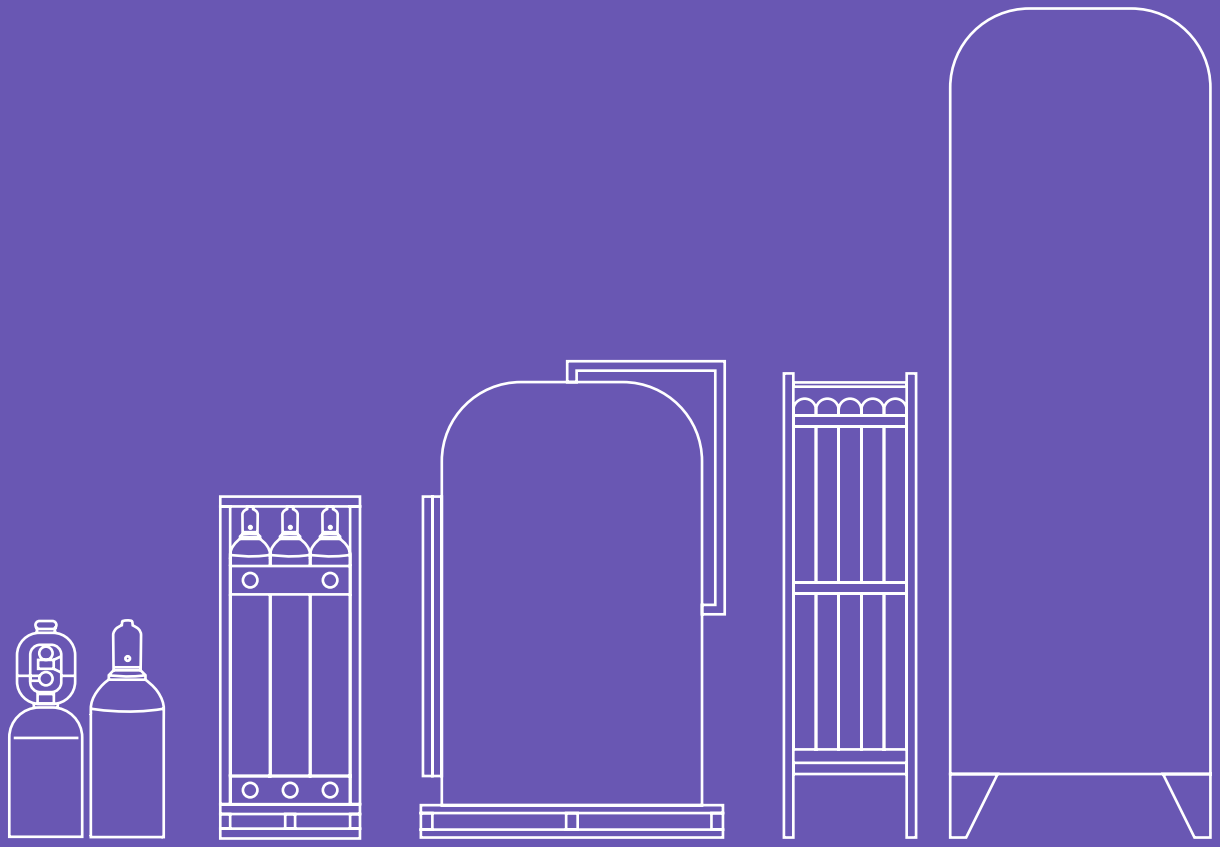
# The right supply has many forms

ADDITIVE MANUFACTURING



NIPPON GASES

# Reliable

## Gas supply from Nippon Gases

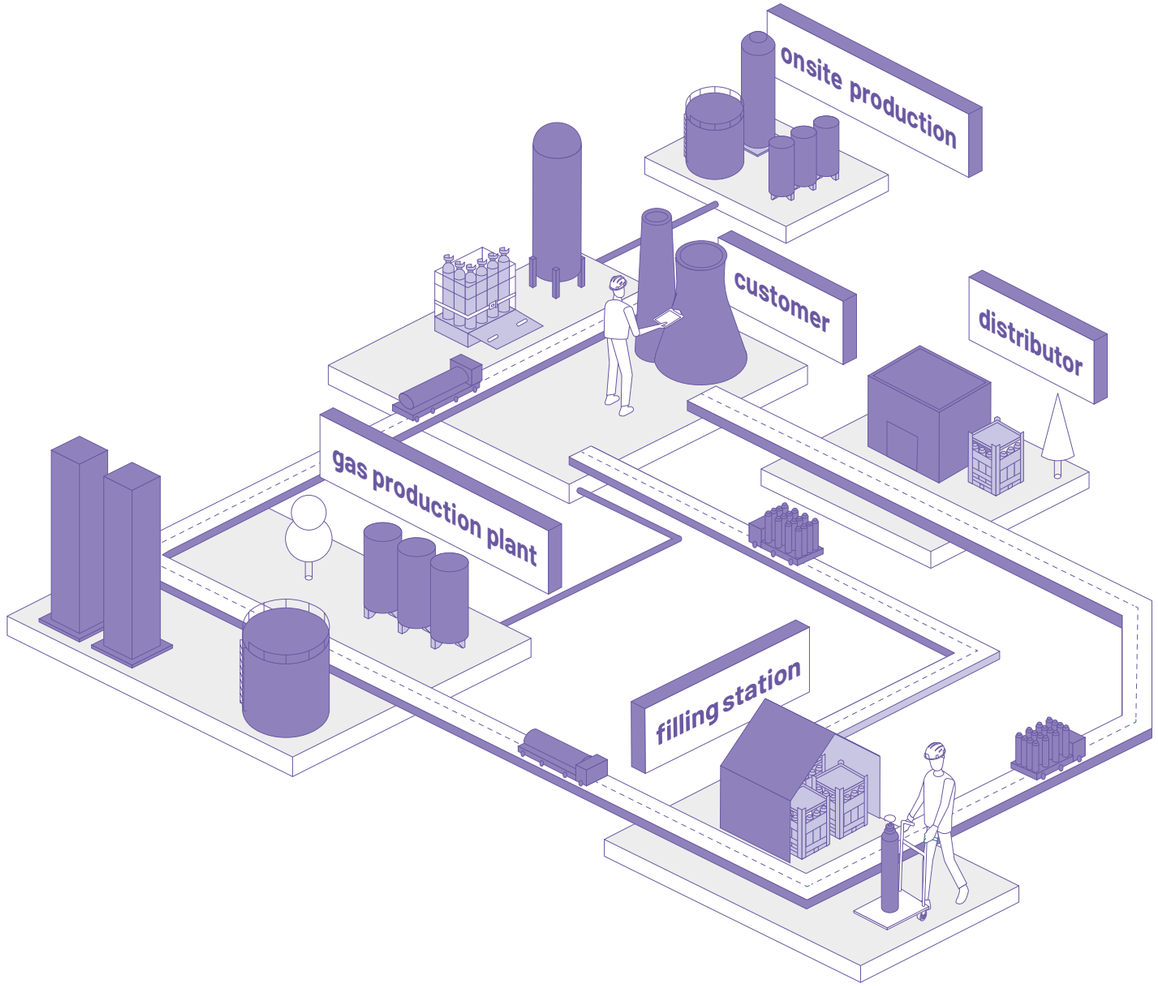
**Nippon Gases is more than just a supplier of industrial gases. As “The Gas Professionals” we are experts in gas manufacturing, gas supply and gas application.**

Nippon Gases is one of the leading industrial gases companies in Europe and is part of Nippon Sanso Holdings Corporation - the parent company of the Japanese Taiyo Nippon Sanso, the American Matheson Tri-Gas Group and the European Nippon Gases.

Our Group was originally founded in 1910 in Tokyo and, since then, we have relentlessly developed our solutions and services for our customers. The key to target-oriented use of industrial gases is a customised analysis of your processes.

Application-orientated advice based on many years of international experience and excellent service, are for us the basis for a trusting customer-supplier relationship.

In everything we do, safety is always at the centre of our considerations. It is an inviolable part of our corporate culture, just as we are committed to protecting the environment and to acting sustainably and ethically.




**Separation of ambient air mainly produces $N_2$, $O_2$, Ar, but also rare gases (Ne, Kr and Xe)**

**Gases can be supplied in different ways:**

- **Pipeline**
- **Truck/tank: as cryogenic liquid**
- **Cylinders: compressed gas or directly produced on-site**

NIPPON GASES

# Versatile

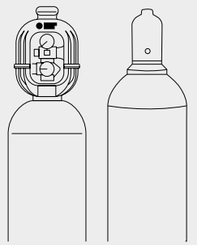
## Tailor-made gas supply

Gases influence the performance of your machines, the efficiency of your processes and ultimately the quality of your products.

It does not matter whether you are producing or researching. Nippon Gases' product range includes all atmospheric gases as well as process and specialty gases. As standard gas or custom-made. From industrial units to high purity gases and gas mixtures.

Ideal for proven processes or new technologies. Whether you need just a single cylinder or thousands of tons per day. With our gases, you're always well supplied.

So that you achieve the results you expect.

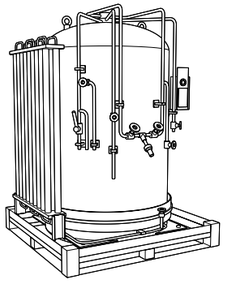


**Installation variant: indoors**

**Cylinders**
The most versatiles

Cylinders are the standard for the wide range of shielding gases.

Plug&Work® is Nippon Gases integrated valve. Thanks to their integrated pressure regulator, cylinders with Plug&Work® are not only ready for use in just three steps, but also very easy to operate.

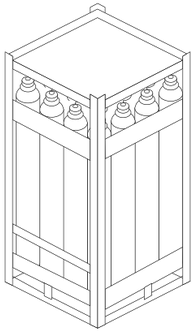


**Installation option: outdoor**

**MicroBulk®**
The medium ones

These tanks close the economic gap for medium consumption. Suitable for central gas supply systems, the product – Ar, $N_2$, $O_2$ and $CO_2$ – is stored liquified in small tanks.

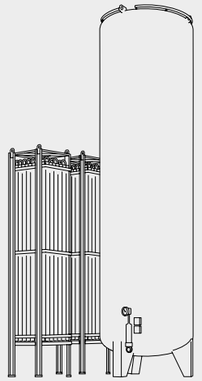
They offer all the advantages of a liquid supply with lower installation and licensing costs. They can be filled on site, and also be connected to gas mixing stations.



**Installation option: indoor or outdoor**

**Bundles**
The small ones

Bundles can be connected to the central gas supply. A bundle is about the size of a Euro-pallet and consist of several individual cylinders piped together with a common outlet.



**Installation option: outdoor**

**Tanks**
The large ones

Vacuum-insulated tank systems are suitable for air gases and connection to central gas supplies. The liquefied product is stored on-site in large quantities.

NIPPON GASES

# Adequate

## Up to the point-of-use.

The choice of the right supply solution directly influences the safety and quality of your operation.

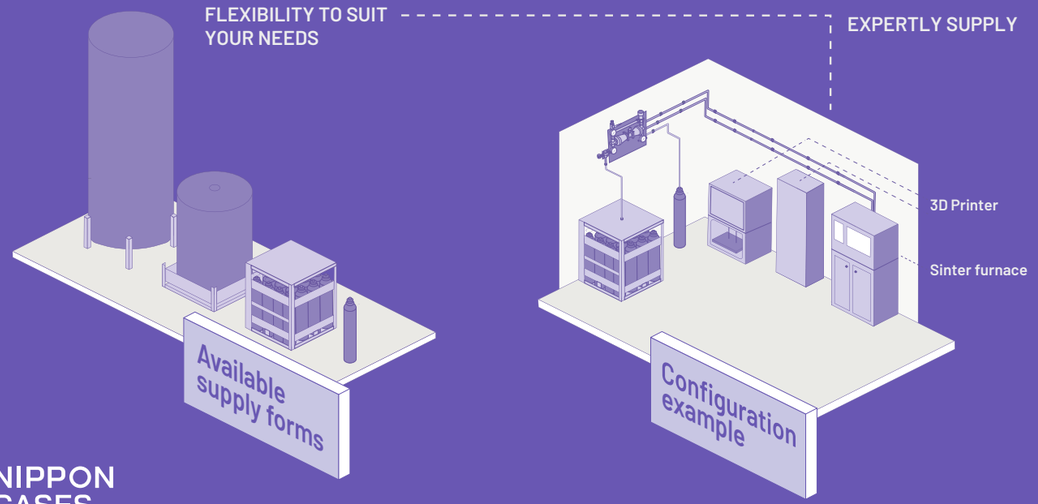
Four criteria are decisive here, especially at the point of use:

- Continuous availability
- Required volume
- Purity
- Compliance with legal requirements for gas supply plants

# Ad-hoc solutions

We analyse your needs based on key questions like:

- Gas supply layout?
- Available installation options/areas?
- Prerequisite for continuous gas supply?
- Material of gas supply line?
- Quality of the tapping/control equipment?




NIPPON GASES

**Our experts therefore support you from A to Z:**

**From the choice of form of supply, via the layout of the accessories to the delivery of the gas at the point of use.**

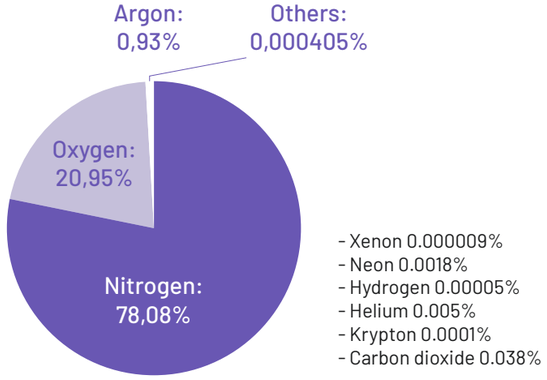
# Where do gases come from?

**Air**

Is a mixture of several gases. Nitrogen, oxygen, argon, carbon dioxide, water vapor and trace amounts of other elements that make up the atmosphere.

**Air Separation Units (ASU)**

Are industrial plants that separate oxygen, nitrogen and argon from all the other components and liquefy them.




- Xenon 0.000009%
- Neon 0.0018%
- Hydrogen 0.00005%
- Helium 0.005%
- Krypton 0.0001%
- Carbon dioxide 0.038%

# The air liquefaction

In 1895, a technical method was patented that enables the liquefaction of air and the separation of the atmospheric components oxygen, nitrogen and argon in larger quantities. Since 1902, this method has been used industrially in air separation plants. Today, the separation process is still based on the Joule-Thomson effect: compression, expansion and cooling.

The different boiling points after purification and cooling are used to separate the air into its main components. This primarily involves the separation of liquid oxygen (LOX) and nitrogen (LIN). Liquid argon (LAR) must be generated by an additional process step in a further separation column.

# Air Separation

## Plant Types

### Cryogenic

#### Distillation

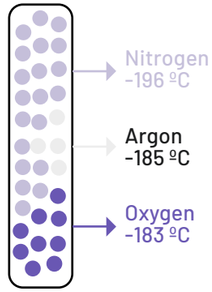
- Air Separation Unit (ASU/ASP)
- Multiproduct ($O_2$, $N_2$, Ar)
- Gas or Liquid
- Base Plant or onsite
- High purity

#### Air Separation Unit (ASU/ASP)

- Multiproduct ($O_2$, $N_2$, Ar)
- Gas or Liquid
- Base Plant or onsite
- High purity

#### N-Plant

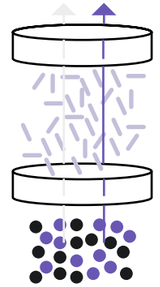
- Single product ($N_2$)
- Gas Supply (no liquid)
- Onsite




### Non-cryogenic

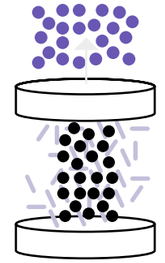
#### Adsorption

Adsorbent retains the undesired gases from the compressed air and allows the desired pure gas to pass



#### VPSA (Vacuum/Pressure Swing Adsorption)

- Single product ($O_2$)
- Gas
- Purity < 95 %
- Onsite



#### PSA (Micro On-site) (Pressure Swing Adsorption)

- Single product ($N_2$)
- Gas
- Purity< 99,5 %
- Onsite

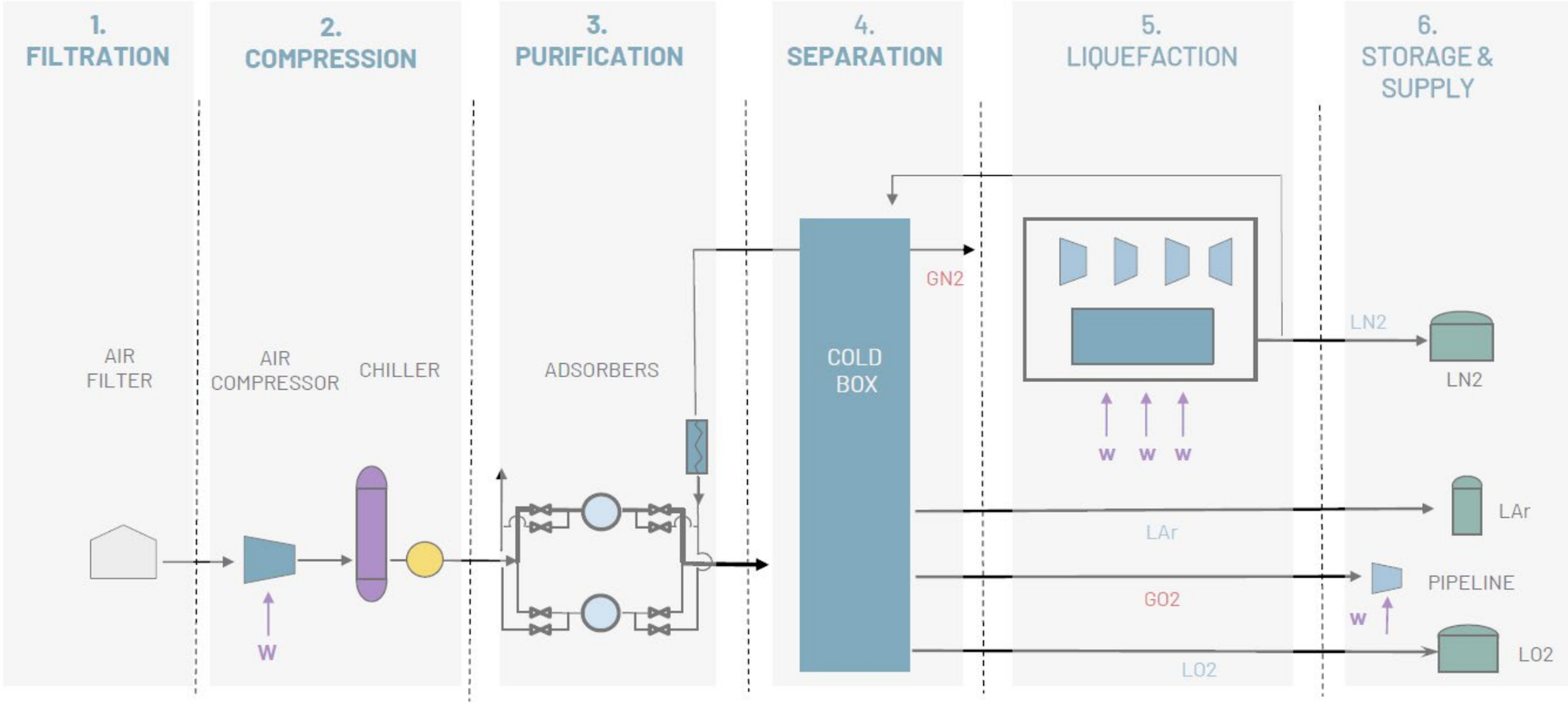
# Air gases properties

**1.** Air gases have different liquefaction temperature or boiling points.

— Oxygen: -183°C
— Argon: - 186°C
— Nitrogen: -196°C

**2.** Air gases compression produces gas heating.
**3.** Air gases expansion produce gas cooling.
**4.** Liquefaction decrease its volumen more than 600 times.

# Process overview



# Air Gases

## Oxygen ($O_2$)

**Density, gaseous (1 bar, 15°C):** 1,34 kg/m$^3$
**Properties:** odourless, tasteless, colourless
**Boiling point:** 183°C

| Extraction: | Oxygen in cylinder: |
|---|---|
| From the liquefaction of air with subsequent distillation | - 10 l, 200 bar / 300 bar<br>- 20 l, 200 bar / 300 bar<br>- 50 l, 200 bar / 300 bar |

| Properties: | Applications: |
|---|---|
| - Oxidising<br>- non-flammable<br>- heavier than air | - Flame cutting, heating, straightening<br>- For combustion<br>- Laser applications with $O_2$ 3.5<br>- Medical gases |

## Nitrogen ($N_2$)

**Density, gaseous (1 bar, 15°C):** 1,17 kg/m$^3$
**Properties:** odourless, tasteless, colourless
**Boiling point:** -196°C

| Extraction: | Nitrogen in cylinder: |
|---|---|
| From the liquefaction of air with subsequent distillation | - 10 l, 200 bar / 300 bar<br>- 20 l, 200 bar / 300 bar<br>- 50 l, 200 bar / 300 bar |

| Properties: | Applications: |
|---|---|
| - Inert<br>- Non-toxic<br>- Non-flammable<br>- Lighter than air<br>- Main-fraction | - Pressurise, inertise, purge<br>- Additive Manufacturing<br>- Gasmixture for beverage industry, food packaging<br>- Lab gas with different purity |

## Argon (Ar)

**Density, gaseous (1 bar, 15°C):** 1,67 kg/m$^3$
**Properties:** odourless, tasteless, colourless
**Boiling point:** -186°C.

| Extraction: | Argon in cylinder: |
|---|---|
| From the liquefaction of air with subsequent distillation | - 10 l, 200 bar / 300 bar<br>- 20 l, 200 bar / 300 bar<br>- 50 l, 200 bar / 300 bar |

| Properties: | Applications: |
|---|---|
| - Inert<br>- Non-combustible<br>- Heavier than air | - Inert gas welding<br>- Additive Manufacturing<br>- Lab gas with different purity |

# Process Gases

## Helium (He)

**Density, gaseous (1 bar, 15°C):** 0,17 kg/m$^3$
**Properties:** Highly flammable
**Boiling point:** -269°C.

| Extraction: | Helium in cylinder: |
|---|---|
| From the liquefaction of air with subsequent distillation | - 3 l to 50 l (200 / 300 bar) |

| Properties: | Applications: |
|---|---|
| - Non-flammable<br>- Colourless noble gas<br>- Lighter than air<br>- Very high thermal conductivity<br>- Noble gas | - Gas mixture for welding<br>- Laboratory gas with different purity<br>- Laser applications<br>- Additive Manufacturing |

## Hydrogen ($H_2$)

**Density, gaseous (1 bar, 15°C):** 0,08 kg/m$^3$
**Properties:** Highly inflammable
**Boiling point:** -253°C.

| Extraction: | Hydrogen in cylinder: |
|---|---|
| - From the chemical industry e.g. chlorinealkali electrolysis<br>- From the oil industry | - Significance in analytics with high purity (200/300 bar)<br>- Gas mixture with nitrogen as forming gas (200/300 bar)<br>- Gas mixture as welding gas (200/300 bar)<br>- Fuel gas in metallurgy (200/300 bar) |

| Properties: | Applications: |
|---|---|
| - Lightest gas<br>- Colourless<br>- Odourless<br>- Highly flammable | - Lab gas with different purity |

## Carbon dioxide ($CO_2$)

**Density, gaseous (1 bar, 15°C):** 1,85 kg/m$^3$
**Properties:** odourless, tasteless, colourless
**Boiling point:** -78°C.

| Extraction: | Carbon dioxide in cylinder: |
|---|---|
| - From combustion processes in the chemical industry<br>- From natural sources | - Liquid in the bottle below 31°C<br>- At room temperature cylinder pressure approx. 60 bar<br>- Different bottles for gas and liquid extraction (riser tube) |

| Properties: | Applications: |
|---|---|
| - 0.04% in air<br>- Non-flammable<br>- Heavier than air<br>- Good solubility in water | - Beverage carbonation<br>- Fire extinguishing agents<br>- Medical gases<br>- Welding (C18) |

## Acetylene ($C_2H_2$)

**Density, gaseous (1 bar, 15°C):** 1,09 kg/m³
**Properties:** Highly flammable, colourless
**Boiling point:** -84,7°C.

| Extraction: | Acetylene in cylinder: |
|---|---|
| - Made from carbide and water<br>- Synthetic | The bottle contains calcium silicate hydrate as a porous mass. This is impregnated with acetone, which in turn can dissolve large amounts of acetylene |
| **Properties:** | **Applications:** |
| - Explosion limit: 2.3 - 82 vol.% (air)<br>- Water solubility: At 20°C 1 litre ethyne/l water<br>- Other solubilities: Very good in acetone and alcohol | - Fuel gas |

## Neon (Ne)

**Density, gaseous (1 bar, 15°C):** 0,842 kg/m³
**Properties:** Odourless, colourless
**Boiling point:** -246°C.

| Extraction: | Neon in cylinder: |
|---|---|
| From the liquefaction of air with subsequent distillation | - 10 l (200 bar)<br>- 50 l (165 / 200 bar) |
| **Properties:** | **Applications:** |
| - Inert<br>- Non-flammable<br>- Noble gas | - Laser gases for electronics |

## Krypton (Kr)

**Density, gaseous (1 bar, 15°C):** 3,51 kg/m³
**Properties:** odourless, colourless
**Boiling point:** -153°C.

| Extraction: | Krypton in cylinder: |
|---|---|
| - From the liquefaction of air with subsequent distillation | - 2 l (82 bar)<br>- 10 l (82 / 144 bar)<br>- 50 l (144 bar) |
| **Properties:** | **Applications:** |
| - Inert<br>- Non-flammable<br>- Non-toxic<br>- Noble gas | - Gas for lamp fillings<br>- Filling for insulating glass<br>- Surface treatment for tools<br>- Research<br>- Laser gases for electronics<br>- Ion propulsion for satellities |

## Xenon (Xe)

**Density, gaseous (1 bar, 15°C):** 5,51 kg/m³
**Properties:** odourless, colourless
**Boiling point:** -108°C.

| Extraction: | Carbon dioxide in cylinder: |
|---|---|
| From the liquefaction of air with subsequent distillation | - 2 l (58,4 bar)<br>- 10 l (58,4 bar)<br>- 50 l (58,4 bar) |
| **Properties:** | **Applications:** |
| - Noble gas<br>- Xenon reacts directly with fluorine only | - Gas for lamp fillings<br>- Filling for insulating glass<br>- Surface treatment for tools<br>- Research<br>- Laser gases for electronics<br>- Ion propulsion for satellities |

# Properties of Cryogenic gases

Conversion table for cryogenic liquefied gases

| | | | | |
|---|---|---|---|---|
| Oxygen<br>$O_2$ | 90,05 K<br>-183,10 °C<br>Boiling temperature at 1 bar | 1 m³<br>1 l<br>1 kg | ≙ 1.171 /<br>≙ 0.854 m³<br>≙ 0.748 m³ | ≙ 1.337 kg<br>≙ 1.142 kg<br>≙ 0.876 l |
| Nitrogen<br>$N_2$ | 90,05 K<br>-183,10 °C<br>Boiling temperature at 1 bar | 1 m³<br>1 l<br>1 kg | ≙ 1.449 /<br>≙ 0.690 m³<br>≙ 0.855 m³ | ≙ 1.170 kg<br>≙ 1.808 kg<br>≙ 1.238 l |
| Argon<br>Ar | 90,05 K<br>-183,10 °C<br>Boiling temperature at 1 bar | 1 m³<br>1 l<br>1 kg | ≙ 1.198 /<br>≙ 0.835 m³<br>≙ 0.599 m³ | ≙ 1.669 kg<br>≙ 1.395 kg<br>≙ 0.717 l |
| Carbon dioxide<br>$CO_2$ | 90,05 K<br>-183,10 °C<br>Boiling temperature at 1 bar | 1 m³<br>1 l<br>1 kg | ^ 1.757 /<br>^ 0.569 m³<br>^ 0.541 m³ | ≙ 1.849 kg<br>≙ 1.052 kg<br>≙ 0.951 l |

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