Gases & Applications

Foreword

This book – Gases and Applications – has been produced to give a brief insight into the broad range of applications our gases have. It also provides information on the different grades, or specifications, of the gases which are necessary to support these many applications.

New applications for gases are continuously emerging as technologies develop and industries change. One important trend, however, is the need for higher specifications for the gases as applications become more exacting and sensitive to contaminants. This book concentrates on the higher specifications of gases that are now available. Your local Linde representative would be delighted to discuss these with you and provide you with more information.

Enjoy the read and we are happy to receive any feedback on our HiQ® website. (http://hiq.linde-gas.com)

Linde
Merchant and Packaged Gases

Contents

Introduction to the 2015 edition

This book was revised to provide an insight into the range of gas purities that are offered by Linde plc, particularly the specialty gases and chemical gases with their HiQ® branding.

The purity specifications for each gas have been enhanced to provide typical purity and impurity data whilst new tables have been added to indicate typical packages and equipment which could be expected to be available for these gases.

Each gas is classified according to the Globally Harmonized System of Classification of Chemicals (GHS) currently being implemented by countries around the world, with the European GHS being taken as reference.

Disclaimer

Linde reserves the right to make alterations to specifications, quantities, etc., for production or other reasons, subsequent to publication.

The information contained herein has been prepared by qualified experts at Linde. While we believe that the information is accurate within the limits of the analytical methods employed, and complete to the extent of the specific analyses performed, we make no warranty or representation as to the suitability of the use of the information for any particular purposes.

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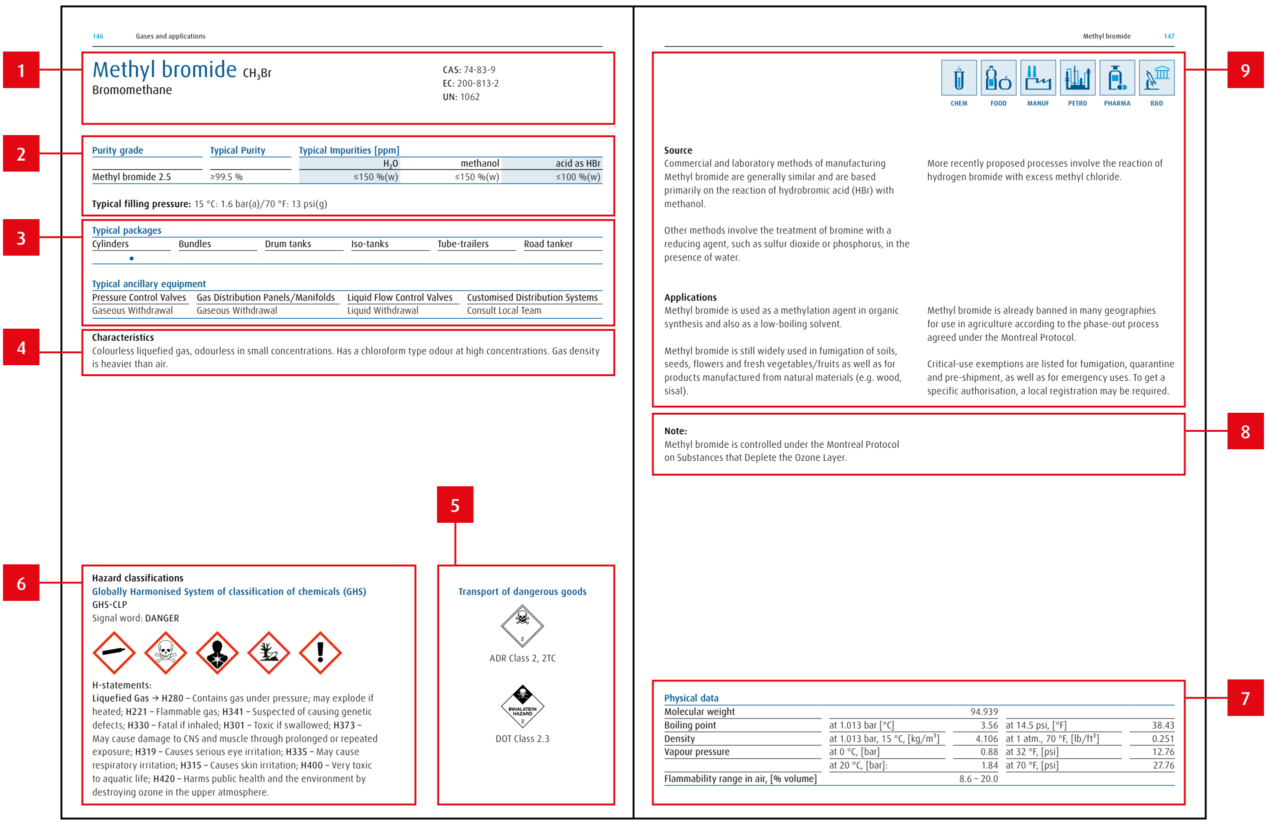
How to use this book

To identify a gas:

- The gases are listed in alphabetical order. See the cross references in the index to find alternative names.
- → In the index there are lists according to CAS and EC numbers.
- → Using the cross reference register, you can easily identify the gases used for each application area.

To read the gas information page:



1) Names, chemical formula, CAS, EC, UN, R numbers

- → The CAS number is a unique numerical identifier for chemical elements (CAS=Chemical Abstracts Service – a division of the American Chemical Society).
- → The EC number (European Commission number) is a seven-digit code that is assigned to chemical substances that are commercially available within the European Union.
- → The UN number is a four-digit number assigned by the United Nations to identify dangerous goods. UN numbers range from UN1001 to UN3500 and are published as part of the UN's Recommendations on the Transport of Dangerous Goods (also known as the Orange Book) and have generally been adopted by member states.
- → Where applicable, R-codes have been provided for the substances. This coding system was introduced by ASHRAE, which stands for American Society of Heating, Refrigerating and Air-Conditioning Engineers.

2) Gas specification table

- Purity classification is written in two ways:
  - a) As a quality code, e.g. 4.5 – where the number before the dot represents the number of nines and the last number indicates the last decimal.
    4.5 = 99.995%
    5.7 = 99.9997%
  - b) As a purity in percent, e.g. > 99.9995%

  This represents the minimum concentration of actual gas. In the case of liquefied gases, the purity always represents the liquid phase. Purities and impurities are given as mol %, mol ppm, mol ppb unless otherwise stated.

- Under the heading "Impurities", the maximum concentrations of specified impurities are stated for the listed typical product specification. The actual concentration can be less. In the case of liquefied gases, the impurity specifications are based on the vaporised liquid phase.

3) Typical packages and ancillary equipment tables

- The typical packages table indicates the common types of packages the gases can be supplied in. Other packages could be available but those indicated are common in our industry.

- The typical ancillary equipment table indicates the types of distribution equipment that should be considered when planning to use a gas. Ancillary equipment requirements should be discussed with your local Linde representative.

4) Characteristic properties

- The short summary of characteristics includes information such as colour, odour and main physical and chemical properties.

5) Transport hazard symbols

→ Hazard symbols for transportation of dangerous goods are based on the United Nations Recommendation. In this book the standards for the road transportation of gases applicable in Europe and the United States of America are shown as examples.

ADR symbols (EU standard)

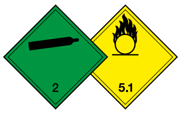
Primary labels:

Non-combustible

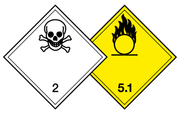
Flammable

Toxic

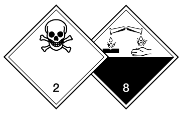
Combination labels:



Non-combustible/Oxidising



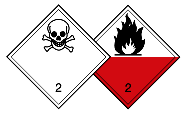
Toxic/Oxidising



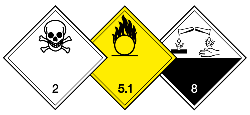
Toxic/Corrosive

Toxic/Flammable

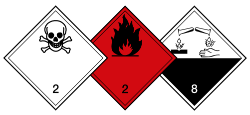
Flammable/Self igniting



Toxic/Self igniting



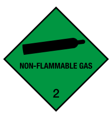
Toxic/Oxidising/Corrosive



Toxic/Flammable/Corrosive

DOT symbols (US standard)

Primary labels:

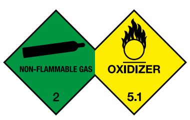


Non-combustible

Flammable

Toxic

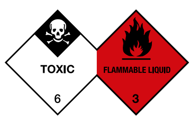
Combination labels:



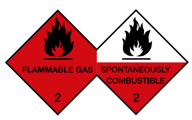
Non-combustible/Oxidising

Toxic/Oxidising

Toxic/Corrosive

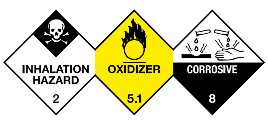


Toxic/Flammable

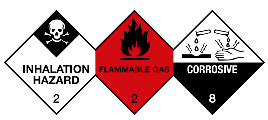


Flammable/Self igniting

Toxic/Self igniting



Toxic/Oxidising/Corrosive



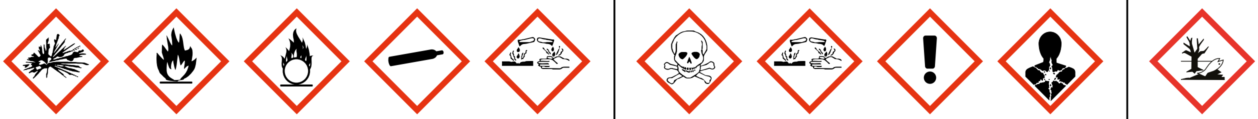
Toxic/Flammable/Corrosive

→ Note that national and local laws and regulations regarding transport and packaging of hazardous materials must be followed at all times. The hazard symbols shown in this book may vary in certain regions and countries.

6) Globally Harmonized System (GHS)

→ According to the new Globally Harmonized System for Classification and Labelling of Chemicals (GHS) issued by the United Nations, the following pictograms are used to identify the hazards of substances and mixtures on the product information documents, i.e. package labels and safety data sheets:

Physical hazards | Health hazards | Environmental hazards



Explosive | Flammable | Oxidising | Gas under pressure | Corrosive | Toxic | Corrosive | Irritant/ Sensitiser | Respiratory (and other)

Furthermore, a signal word (DANGER/WARNING) needs to be assigned; Hazard (H-) statements are replacing Risk (R-) phrases, and Precautionary (P-) statements are replacing Safety (S-) phrases. Appendix 02 shows a correspondence table between R-phrases and old EC symbols vs. the new S-statements and the new GHS symbols.

Transport of dangerous goods diamonds are not affected by the GHS. In the case of a single package, GHS pictograms may not be used if they duplicate transport of dangerous goods pictograms.

The European GHS entered into force on 20 January 2009 (Regulation No 1272/2008 on classification, labelling and packaging – called GHS-CLP in this book); all products shall be classified and labelled in accordance with GHS-CLP criteria:

- by 1 December 2010 for all pure substances,
- by 1 June 2015 for all mixtures.

In cases where GHS-CLP does not provide an official classification, the classification proposed by industry, i.e. by EIGA (European Industrial Gas Association) or the REACH Regulation is taken into consideration in this book.

7) Physical data

→ Physical data reproduced by permission of the Design Institute for Physical Properties (DIPPR), under the auspices of the American Institute of Chemical Engineers.

→ When nothing else is stated, the pressure is absolute.

8) International agreements

→ The Montreal Protocol (1987) on Substances that Deplete the Ozone Layer. This international agreement, signed by almost 200 countries, will lead to the eventual total phase-out of chlorofluorocarbons (CFC), halons, hydrobromofluorocarbons (HBFC), methyl chloroform, carbon tetrachloride, hydrochlorofluorocarbons (HCFC) and methyl bromide.

Total bans or production caps and import quotas now apply to all categories of ozone-depleting products (ODP) in all signatory developed countries.

In developing countries, high-ODP products are currently subject to control. Regulation of lower-ODP products is scheduled to apply by 2015.

Some territories (e.g. EU) have already imposed application-specific usage bans ahead of the Montreal Protocol schedule.

Certain exemptions apply for essential uses (e.g. laboratory, medical and military) and non-emissive applications (e.g. as feedstock in production processes).

- **The Kyoto Protocol (1997)** is an international Framework Convention on Climate Change with the objective of reducing greenhouse gases in an effort to prevent anthropogenic climate change.

  The scope of the protocol covers a "basket of six" identified greenhouse gases: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons (HFC) and perfluorocarbons (PFC).

  Some territories (e.g. EU) have already imposed tighter emissions limits and application-specific usage bans ahead of the Kyoto Protocol schedule. Other countries (e.g. USA) are considering limiting the production and import of some of the products covered by the Protocol.

  Carbon dioxide is the baseline unit to which all other greenhouse gases are related. Therefore carbon dioxide has a Global Warming Potential (GWP) of 1.

- **The Rotterdam Convention (1998)** is a multilateral treaty to promote shared responsibility and cooperative efforts among parties in the international trade of certain hazardous chemicals. Its objectives are to protect human health and the environment from potential harm and to contribute to the environmentally sound use of these chemicals by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to the relevant parties.

  Some territories have issued specific regulations to implement the requirements of the Convention, for example the PIC (Prior Informed Consent) Regulation in the EU.

9) Source and applications

- The application icons on the top right of the page summarise the applications the gas is used for. The source and applications paragraphs provide some examples of how the gases can be manufactured and used. See the "Application areas and product sources" paragraph for more details.

- In some geographies, certain applications may need to comply with specific regulatory requirements such as registration or authorisation. This is for example the case for gases used in medical applications or as pesticides and biocides.

Appendix 01 – Material compatibility table

For most gas types, there are recommendations on suitable materials when selecting equipment. The information has been compiled from what Linde believes to be reliable sources (International Standards: Compatibility of cylinder and valve materials with gas content; Part 1: ISO 11114-1, Part 2: ISO 11114-2). The data must be used with caution. Raw data such as this cannot cover all conditions in relation to concentration, temperature, humidity, impurities and aeration. This table should be used as a guideline to choose possible materials, after which more extensive investigation and testing should be carried out under the specific conditions of use. The data mainly refers to high-pressure applications at ambient temperature and the safety aspect of material compatibility rather than the quality aspect. For more specific information and for information not contained in this book please contact your Linde representative.

Application areas and product sources

In this book we have divided the market into thirteen application areas. These areas are represented by icons placed beside the application text if the area is using the gas in question. The division is based on ISIC codes, and is therefore aligned with published statistics.

The applications mentioned in this book are examples of how the gases can be used. Gases find their ways into new application fields as the market grows and techniques become more refined. Therefore new applications evolve and old applications disappear. In this respect the book is a snapshot at the time of compilation.

Product sources given in this book are not exhaustive, but rather examples of common possible ways of producing the substances.

Note that purity levels and impurities shown on the left-hand pages are examples from our broad specialty gases range. Some applications might need a higher purity than mentioned and in other cases a lower purity may be sufficient for a certain application or process.

Linde can deliver most pure gases and a large variety of gas mixtures at all required purity levels. Please contact your local Linde representative or visit HiQ.Linde-Gas.com for our full range of HiQ® specialty gases.

Cross reference register

AUTO, automotive and transport-related industries

AUTO

Acetylene
Air, synthetic
Ammonia
Argon
n-Butane
iso-Butane
Carbon dioxide
Carbon monoxide
Carbonyl sulfide
Epoxyethane
Ethane
Ethene
Fluorine
Helium
Methane
Nitric oxide
Nitrogen dioxide
Nitrous oxide
Oxygen
Propane
Propylene
Sulfur dioxide
Sulfur hexafluoride
Xenon

CHEM, chemical industries except petrochemical and pharmaceutical

CHEM

Acetylene
Aminomethane
Ammonia
Boron trichloride
Boron trifluoride
Bromoethene
1,3-Butadiene
n-Butane
iso-Butane
1-Butene
cis-2-Butene
iso-Butene
trans-2-Butene
1-Butyne
Carbon dioxide
Carbon monoxide
Carbon oxyfluoride
Carbonyl sulfide
Chlorine
1-Chloro-1,1-difluoroethane
1-Chloro-1,2,2,2-tetrafluoroethane
Chlorodifluoromethane
Chloroethene
Chloropentafluoroethane
Cyanic chloride
Cyclopentane
Cyclopropane
Deuterium
Diborane
1,1-Dichloro-1-fluoroethane
2,2-Dichloro-1,1,1-trifluoroethane
Dichlorofluoromethane
Dichlorosilane
1,1-Difluoroethane
1,1-Difluoroethene
Dimethylamine
2,2-Dimethylpropane
Epoxyethane
Ethanamine
Ethane
Ethanedinitrile
Ethene
Ethyl chloride
Ethyl formate
Fluorine
1,1,1,2,3,3,3-Heptafluoropropane
Hexafluoroethane
1,1,1,3,3,3-Hexafluoropropane
Hydrogen
Hydrogen bromide
Hydrogen chloride
Hydrogen cyanide
Hydrogen fluoride
Hydrogen iodide
Hydrogen sulfide
Methane
Methoxyethene
Methoxymethane
Methyl bromide
Methyl chloride
Methyl formate
Methyl mercaptan
Nitric oxide
Nitrogen
Nitrogen dioxide
Nitrogen trifluoride
Nitrous oxide
Oxygen
Pentafluoroethane
1,1,1,3,3-Pentafluoropropane
n-Pentane
iso-Pentane
Phosgene
Phosphine
Propadiene
Propane
Propylene
Propyne
Silicon tetrachloride
Silicon tetrafluoride
Sulfur dioxide
2,3,3,3-Tetrafluoro-1-Propylene
trans-1,3,3,3-Tetrafluoro-1-Propylene
Tetrafluoromethane
Trichlorosilane
Trifluoroethane
Trimethylamine
Xenon

CONSTR, construction

CONSTR

Acetylene
Air, synthetic
Ammonia
Argon
n-Butane
iso-Butane
Carbon Dioxide
1-Chloro-1,1-difluoroethane
1-Chloro-1,2,2,2-tetrafluoroethane
Chlorodifluoroethane
Chlorodifluoromethane
Chloroethene
Chloropentafluoroethane
Cyclopentane
1,1-Dichloro-1-fluoroethane
2,2-Dichloro-1,1,1-trifluoroethane
Dichlorodifluoromethane
1,2-Dichlorotetrafluoroethane
1,1-Difluoroethane
Dimethyl ether
Ethane
Ethyl chloride
Ethylene
Fluoromethane
Helium
1,1,1,2,3,3,3-Heptafluoropropane
Hexafluoroethane
1,1,1,3,3,3-Hexafluoropropane
Krypton
Methane
Methyl formate
Nitrogen
Octafluoropropane
Oxygen
Pentafluoroethane
1,1,1,3,3-Pentafluoropropane
n-Pentane
iso-Pentane
Propane
Propylene
Sulfur hexafluoride
2,3,3,3-Tetrafluoro-1-Propylene
trans-1,3,3,3-Tetrafluoro-1-Propylene
Tetrafluoroethane
Tetrafluoromethane
Trifluoroethane
Trifluoromethane
Xenon

ENERGY, electricity, gas and water

ENERGY

Air, synthetic
Ammonia
n-Butane
iso-Butane
Carbon dioxide
Carbon monoxide
Carbonyl sulfide
Chlorine
Chloroethene
Deuterium
Dichlorodifluoromethane
1,2-Dichlorotetrafluoroethane
Ethane
Helium
Hexafluoroethane
Hydrogen
Hydrogen sulfide
Methane
Nitric oxide
Nitrogen
Nitrogen dioxide
Nitrous oxide
Octafluoropropane
Oxygen
Propane
Propylene
Silicon tetrafluoride
Sulfur dioxide
Sulfur hexafluoride

FOOD, food, beverages and agriculture

FOOD

Acetylene
Aminomethane
Ammonia
Argon
Bromoethene
iso-Butane
Carbon dioxide
Carbon monoxide
Carbonyl sulfide
1-Chloro-1,1-difluoroethane
1-Chloro-1,2,2,2-tetrafluoroethane
Cyclopentane
1,1-Dichloro-1-fluoroethane
2,2-Dichloro-1,1,1-trifluoroethane
Dichlorodifluoromethane
Dimethylamine
Epoxyethane
Ethanedinitrile
Ethene
Ethyl formate
1,1,1,2,3,3,3-Heptafluoropropane
1,1,1,3,3,3-Hexafluoropropane
Hydrogen
Hydrogen cyanide
Hydrogen fluoride
Methane
Methyl bromide
Methyl formate
Methyl mercaptan
Nitrogen
Nitrous oxide
Oxygen
Pentafluoroethane
1,1,1,3,3-Pentafluoropropane
n-Pentane
iso-Pentane
Phosphine
Propane
Sulfur dioxide
2,3,3,3-Tetrafluoro-1-Propylene
trans-1,3,3,3-Tetrafluoro-1-Propylene
Trifluoroethane

MANUF, manufacturing industries except automotive and OEM

MANUF

Acetylene
Air, synthetic
Aminomethane
Ammonia
Argon
Boron trichloride
Bromoethene
n-Butane
iso-Butane
Carbon dioxide
Carbon monoxide
Chlorine
Chlorodifluoroethane
Chlorodifluoromethane
Chloroethene
Chloropentafluoroethane
Cyclopentane
Deuterium
Diborane
Dichlorodifluoromethane
Dichlorofluoromethane
1,2-Dichlorotetrafluoroethane
1,1-Difluoroethane
Difluoromethane
Dimethylamine
Epoxyethane
Ethane
Ethanedinitrile
Ethene
Ethyl chloride
Ethyl formate
Fluorine
Fluoromethane
Helium
Hexafluoroethane
Hydrogen
Hydrogen bromide
Hydrogen chloride
Hydrogen cyanide
Hydrogen fluoride
Hydrogen sulfide
Krypton
Methane
Methyl mercaptan
Methoxyethene
Methoxymethane
Methyl bromide
Methyl chloride
Methyl formate
Neon
Nitrogen
Nitrogen trifluoride
Nitrous oxide
Octafluoropropane
Oxygen
n-Pentane
iso-Pentane
Phosgene
Phosphine
Propane
Propylene
Silane
Silicon tetrachloride
Sulfur dioxide
Sulfur hexafluoride
trans-1,3,3,3-Tetrafluoro-1-Propylene
Tetrafluoroethane
Tetrafluoromethane
Trifluoromethane
Xenon

Cross reference register

MEDICAL, hospitals and healthcare

MEDICAL

- Acetylene
- Air, synthetic
- Argon
- Carbon dioxide
- Carbon monoxide
- Cyclopropane
- Deuterium
- Epoxyethane
- Ethene
- Ethyl chloride
- Helium
- 1,1,1,2,3,3,3-Heptafluoropropane
- Krypton
- Methyl chloride
- Neon
- Nitric oxide
- Nitrogen
- Nitrous oxide
- Octafluoropropane
- Oxygen
- Sulfur hexafluoride
- Trimethylamine
- Xenon

METAL, metal industries

METAL

- Air, synthetic
- Ammonia
- Argon
- Boron trichloride
- Boron trifluoride
- Bromoethene
- iso-Butane
- Carbon dioxide
- Carbon monoxide
- Chlorine
- Diborane
- Dimethylamine
- Ethane
- Fluorine
- Helium
- Hydrogen
- Hydrogen chloride
- Hydrogen fluoride
- Hydrogen sulfide
- Methane
- Methyl chloride
- Nitrogen
- Nitrogen trifluoride
- Oxygen
- Propane
- Silicon tetrachloride
- Silicon tetrafluoride
- Sulfur dioxide
- Sulfur hexafluoride

OEM, original analytical equipment manufacturers

OEM

- Acetylene
- Air, synthetic
- Ammonia
- Argon
- n-Butane
- iso-Butane
- Carbon dioxide
- Carbon monoxide
- 2,2-Dimethylpropane
- Helium
- Hydrogen
- Hydrogen cyanide
- Krypton
- Methane
- Neon
- Nitric oxide
- Nitrogen
- Nitrogen dioxide
- Nitrous oxide
- Oxygen
- Propane
- Sulfur Hexafluoride
- Xenon

PETRO, petrochemical industries

PETRO

- Acetylene
- Aminomethane
- Ammonia
- Boron trichloride
- Boron trifluoride
- Bromoethene
- 1,3-Butadiene
- n-Butane
- iso-Butane
- 1-Butene
- cis-2-Butene
- iso-Butene
- trans-2-Butene
- 1-Butyne
- Carbon dioxide
- Carbon monoxide
- Chlorine
- 1-Chloro-1,1-difluoroethane
- 1-Chloro-1,2,2,2-tetrafluoroethane
- Chlorodifluoromethane
- Cyclopentane
- Cyclopropane
- Diborane
- 1,1-Dichloro-1-fluoroethane
- 2,2-Dichloro-1,1,1-trifluoroethane
- 1,1-Difluoroethane
- 1,1-Difluoroethene
- Dimethylamine
- 2,2-Dimethylpropane
- Epoxyethane
- Ethanamine
- Ethane
- Ethene
- Ethyl chloride
- Fluorine
- 1,1,1,2,3,3,3-Heptafluoropropane
- Hexafluoroethane
- 1,1,1,3,3,3-Hexafluoropropane
- Hydrogen
- Hydrogen bromide
- Hydrogen chloride
- Hydrogen fluoride
- Hydrogen sulfide
- Methane
- Methoxyethene
- Methoxymethane
- Methyl bromide
- Methyl chloride
- Methyl formate
- Methyl mercaptan
- Nitric oxide
- Nitrogen
- Oxygen
- Pentafluoroethane
- 1,1,1,3,3-Pentafluoropropane
- n-Pentane
- iso-Pentane
- Phosgene
- Propadiene
- Propane
- Propylene
- Propyne
- Sulfur dioxide
- 2,3,3,3-Tetrafluoro-1-Propylene
- trans-1,3,3,3-Tetrafluoro-1-Propylene
- Tetrafluoroethane
- Trifluoroethane
- Trimethylamine

PHARMA, pharmaceutical industries

PHARMA

Air, synthetic
Aminomethane
Ammonia
Argon
Boron trichloride
Boron trifluoride
Bromoethene
Carbon dioxide
Carbonyl sulfide
Dimethylamine
Epoxyethane
Ethanamine
Ethyl formate
1,1,1,2,3,3,3-Heptafluoropropane
Hydrogen
Hydrogen bromide
Hydrogen chloride
Hydrogen cyanide
Hydrogen sulfide
Methane
Methoxymethane
Methyl bromide
Methyl chloride
Methyl formate
Methyl mercaptan
Nitrogen
Nitrous oxide
Oxygen
Phosgene
Propadiene
Propane
Propylene
Propyne
Sulfur dioxide
Tetrafluoroethane
Trimethylamine

R&D, research institutes and universities

R&D

All gases are used or can be used for research.

SEMI, semiconductor industries

SEMI

Acetylene
Ammonia
Argon
Arsine
Boron trichloride
Boron trifluoride
Carbon dioxide
Chlorine
Chloropentafluoroethane
Deuterium
Diborane
Dichlorosilane
1,2-Dichlorotetrafluoroethane
Difluoromethane
Fluorine
Fluoromethane
Helium
Hexafluoroethane
Hydrogen
Hydrogen bromide
Hydrogen chloride
Hydrogen fluoride
Hydrogen iodide
Hydrogen sulfide
Krypton
Methyl chloride
Neon
Nitric oxide
Nitrogen
Nitrogen trifluoride
Nitrous oxide
Octafluoropropane
Oxygen
Phosphine
Silane
Silicon tetrachloride
Silicon tetrafluoride
Sulfur hexafluoride
Tetrafluoromethane
Trichlorosilane
Trifluoromethane
Xenon

Acetylene C_2H_2

Ethyne

CAS: 74-86-2
EC: 200-816-9
UN: 1001

Purity grade	Typical purity	Typical impurities [ppm]		
		Air	PH_3	H_2S
HiQ® Acetylene 2.6 AAS	≥99.6 %	≤4,000	≤5	≤1

Typical filling pressure: 15 °C: 15 bar(a)/ 70 °F: 250 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless gas with ether-like odour when very pure, otherwise garlic-like. Supplied dissolved in acetone or DMF (n,n-dimethylmethanamide). Can decompose instantaneously at pressures higher than 1 bar. Acetylene can be delivered as a non-dissolved gas for specific R&D applications. Gas density is slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

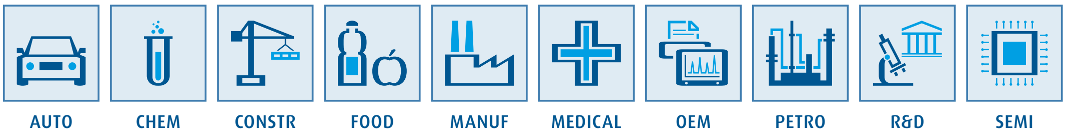
H-statements:

Dissolved Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H230** – May react explosively even in the absence of air.

Transport of dangerous goods

ADR Class 2, 4F

DOT Class 2.1



Source

Acetylene is manufactured commercially by reaction between calcium carbide and water, and as a by-product of ethylene production.

Applications

Acetylene is used as a raw material for the production of electrically conducting plastics, such as polyacetylene.

Acetylene is used with high purity synthetic air or nitrous oxide as a fuel for the flame in atomic absorption flame spectroscopy. This is used in water, soil, food and biological research laboratories where sensitivity and accuracy of results are important.

Acetylene is most commonly used in combination with oxygen for cutting or welding materials such as mild steel, where the standard industrial grade is sufficient. Acetylene with low phosphine levels is required for lead brazing or welding.

Acetylene is used in organic synthesis (laboratory work) as well as in chemical synthesis.

Acetylene is used as carbon source in the production of molecules like fullerenes; well-known examples are buckyballs or carbon nanotubes.

Acetylene is used in the cultivation of plants; it improves the formation of new flowers.

Acetylene is used as a component in calibration gases for the gas, oil and chemical industries.

Acetylene is still used in some lighthouses as light fuel source.

Acetylene is one of the components of lung testing gases.

This unsaturated hydrocarbon exhibits high chemical reactivity, and is an important intermediate in the chemical industry. It is employed for the production of:

→ acetaldehyde
→ acrylic acids
→ acrylic ethers
→ acrylonitride
→ carbazole
→ butenyne (vinyl acetylene)
→ chloroethene (vinyl chloride)
→ diols
→ ethene
→ ethenoxyethenes (vinyl ethers)
→ ethenyl acetate (vinyl acetate)
→ ethenyl amides (vinyl amides)
→ ethenyl sulfides (vinyl sulfides)
→ neoprene
→ phenylethene (styrene)
→ polyoxymethylene
→ pyrrolidine
→ trichloroethene
→ very fine carbon black, called “acetylene black”.

Physical data

Molecular weight		26.038		
Boiling point	at 1.013 bar [°C]	−84.15	at 14.5 psi [°F]	−241.17
Density	at 1.013 bar, 15 °C [kg/m^3]	1.109	at 1 atm., 70 °F [lb/ft^3]	0.068
Vapour pressure	at 0 °C [bar]	26.4	at 32 °F [psi]	382.9
	at 20 °C [bar]	43.41	at 70 °F [psi]	646.21
Flammability range in air [% volume]		2.3 – 88.0		

Air, synthetic 80 % N_2 + 20 % O_2

Synthetic air

CAS: 132259-10-0
EC: not available
UN: 1002

Legend: N/D = Not Detectable

Purity grade	Purity	Impurities [ppm] H_2O	C_nH_m	CO	CO_2	NO_x	SO_2	NO + NO_2	Oil	Odour
HiQ® Air 4.0	≥99.99 %	≤5	-	-	-	-	-	-	-	-
HiQ® Synthetic Air 5.0	≥99.999 %	≤5	≤1	-	-	-	-	-	-	-
HiQ® Synthetic Air 5.0 Zero	≥99.999 %	≤3	≤0.2	≤1	≤1	-	-	-	-	-
HiQ® Synthetic Air 5.5	≥99.9995 %	≤2	≤0.1	≤1	≤1	-	-	-	-	-
HiQ® Synthetic Air 5.5 CEM Zero	≥99.9995 %	≤1	≤0.1	≤0.5	≤1	≤0.1	≤0.1	-	-	-
HiQ® Synthetic Air Euro 6 Raw	≥99.999 %	≤5	≤1	≤1	≤1	≤0.1	-	-	-	-
HiQ® Synthetic Air Euro 6 Dilute	≥99.999 %	≤0.5	≤0.05	≤0.1	≤0.1	≤0.02	-	-	-	-
VERISEQ® Process Synthetic Air (pharmaceutical grade)	≥99.5 %	≤67	-	≤10	≤500	-	≤5	≤2.5	≤0.1 mg/m^3	N/D

Typical filling pressure: 15 °C: 200 bar(a)/ 70 °F: 2,400 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

–

Hazard classifications

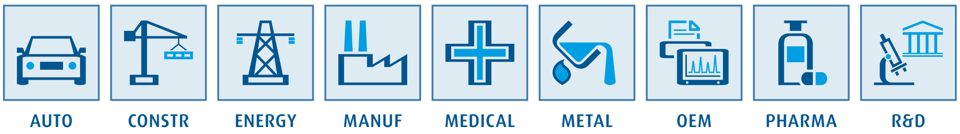
Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Substance not classified as hazardous.

Transport of dangerous goods

ADR Class 2, 1A

DOT Class 2.2



Source

Synthetic air is produced by mixing pure oxygen (20 %) and pure nitrogen (80 %). This eliminates all kind of impurities present in normal ambient air.

Applications

Synthetic air is used as a source of oxygen for well defined industrial oxidation processes.

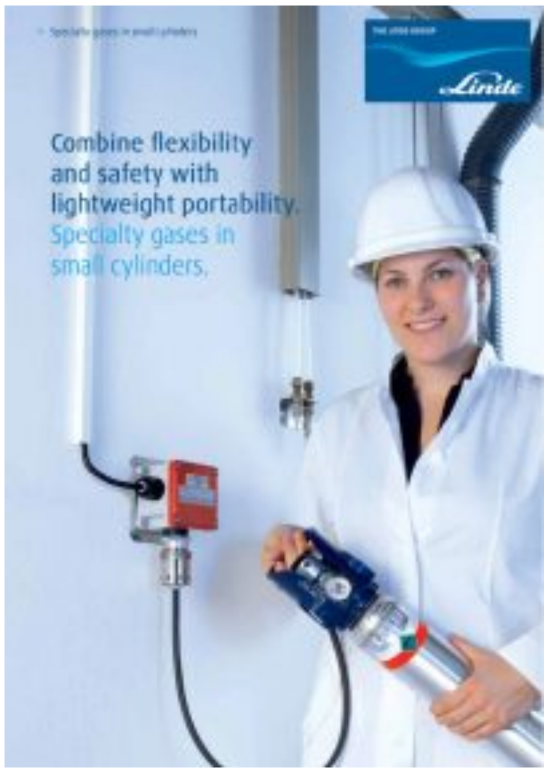
Synthetic air is used as zero gas in the running and calibration of environmental monitoring and test measurements where levels of sulphur and nitric oxides can affect the measurement equipment.

Synthetic air is used in medical gas mixtures. Medical air may be classified as medical gas in some geographies and managed according to the relevant regulations.

Synthetic air is regularly used as the oxidiser for flame ionisation detectors in chromatography and total hydrocarbon analysers.

Synthetic air is used together with acetylene in atomic absorption flame spectrometry.

Synthetic air is used as a balance gas for many calibration gases.



Physical data

Molecular weight		28.975		
Boiling point	at 1.013 bar [°C]	−194.3	at 14.5 psi [°F]	−317.8
Density	at 1.013 bar, 15 °C [kg/m³]	1.21	at 1 atm., 70 °F [lb/ft³]	0.075
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Ammonia NH_3

R-717

CAS: 7664-41-7
EC: 231-635-3
UN: 1005
R-717

Purity grade	Typical purity	Typical impurities [ppm]							
		H_2O	O_2	N_2	CO	CO_2	C_nH_m	Fe	Oil
Ammonia 3.8	≥99.98 %	≤200	-	-	-	-	-	-	≤10 %(w)
HiQ® Ammonia 4.5	≥99.995 %	≤5	≤5	≤30	≤5	≤1	≤2	-	-
HiQ® Ammonia 5.0	≥99.999 %	≤1	≤1	≤4	≤1	≤1	≤1	-	-
HiQ® Ammonia 6.0	≥99.9999 %	≤0.2	≤0.1	≤0.5	≤0.1	≤0.2	≤0.1	≤0.1	-

Typical filling pressure: 15 °C: 7.3 bar(a)/70 °F: 114 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			•

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless flammable liquefied gas with a penetrating and suffocating odour. Gas Density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

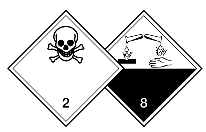
GHS-CLP

Signal word: DANGER

H-statements:

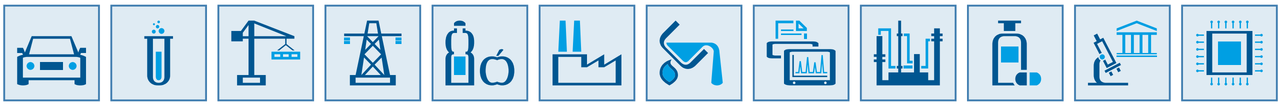
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H221** – Flammable gas; **H331** – Toxic if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract; **H400** – Very toxic to aquatic life.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3



Source

Ammonia is manufactured by the Haber-Bosch process, consisting of a direct reaction between hydrogen and nitrogen in the molar ratio 3:1.

Higher purity grades of ammonia are produced with the help of distillation processes

Applications

Anhydrous ammonia is one of the oldest commercial refrigerants known. It is used in both absorption and compression type systems. It has the ASHRAE number R-717. It is used extensively in soil fertilisation. In this application it is used in the form of ammonia, ammonia nitrates and urea salts. It is also added to fertilisers containing superphosphates and in making nitrogen-containing solutions which consist of ammonia and ammonium nitrate, or urea, or both in water. Anhydrous ammonia is applied to the soil by direct injection or by addition to irrigation water. Anhydrous ammonia is also used in combination with chlorine to purify municipal and industrial water supplies.

Ammonia, or rather dissociated ammonia, is used in such metal treating operations as nitriding, carbo-nitriding, bright annealing, furnace brazing, sintering, sodium hydride descaling, atomic hydrogen welding, and other applications. It is used in extracting such metals as copper, nickel and molybdenum from their ores. It is also used to reduce the atmosphere in heat treatment of metals and for the fabrication of silicium nitride.

Dissociated ammonia is also used as a convenient source of hydrogen for the hydrogenation of fats and oils. Through the controlled combustion of dissociated ammonia in air, a source of pure nitrogen is achieved.

The petroleum industry utilises anhydrous ammonia in neutralising the acid constituents of crude oil, thus protecting equipment such as bubble plate towers, heat exchangers, condensers and storage tanks from corrosion.

Ammonia can be oxidised to nitric oxide, which is converted to nitrogen dioxide to yield nitric acid in a second reaction step (Ostwald process).

In the lead chamber process for manufacturing sulfuric acid, ammonia is oxidised to nitrogen oxides, which are needed to convert sulfur dioxide to sulfuric acid.

Most industrial and military explosives of the conventional types contain nitrogen, with ammonia as the basic source of nitrogen in their production.

As a processing agent, ammonia is used in the manufacturing of alkalis, ammonium salts, dyes, pharmaceuticals, cuprammonium rayon and nylon.

Ammonia:

- → is used in the production of hydrogen cyanide.
- → is a reagent in copying machines (blue print and micro film).
- → is also used to produce proteins and can be used to improve the protein content of low quality hay.
- → is used as a component in calibration gas mixtures for gas detection systems as well as environmental emission monitoring.
- → is widely used in the semiconductor industry.
- → is used in the production of blue and white LEDs (Light Emitting Diodes).
- → can be used to neutralise nitric oxides emitted by diesel engines by selective catalytic reduction.
- → is used as a chemical agent in CG-MS analytical equipment.

Physical data

Molecular weight		17.031		
Boiling point	at 1.013 bar [°C]	−33.43	at 14.5 psi [°F]	−241.17
Density	at 1.013 bar, 15 °C [kg/m³]	0.728	at 1 atm., 70 °F [lb/ft³]	0.044
Vapour pressure	at 0 °C [bar]	4.29	at 32 °F [psi]	62.21
	at 20 °C [bar]	8.55	at 70 °F [psi]	128.51
Flammability range in air [% volume]		15.0 – 30.0		

Argon Ar

CAS: 7440-37-1
EC: 231-147-0
UN: 1006 (Compressed)
UN: 1951 (Refrigerated liquid)
R-740

Purity grade	Purity	Impurities [ppm]								
		H_2O	O_2	C_nH_m	CO	CO_2	N_2	H_2	CH_4	Halocarbons
HiQ® Argon 4.8	≥99.998 %	≤5	≤5	-	-	-	≤10	-	-	-
HiQ® Argon 5.0	≥99.999 %	≤3	≤2	≤0.5	-	-	≤5	-	-	-
HiQ® Argon 5.0 Zero	≥99.999 %	≤3	≤2	≤0.2	≤1	≤1	≤5	-	-	-
HiQ® Argon 6.0	≥99.9999 %	≤0.5	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	≤0.5	-	-
HiQ® Argon 7.0	≥99.99999 %	≤50 ppb	≤30 ppb	≤30 ppb	≤30 ppb	≤30 ppb	-	≤30 ppb	-	≤1 ppb
VERISEQ® Process Argon (pharmaceutical grade)	≥99.998 %	≤0.5	≤5	-	-	-	≤10	-	≤1	-

Typical filling pressure: 15 °C: 200 bar(a)/70 °F: 2,640 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				Cryogenic liquid

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•	Cryogenic liquid	Consult local team

Characteristics
Colourless and odourless gas. Non-reactive. Inert. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

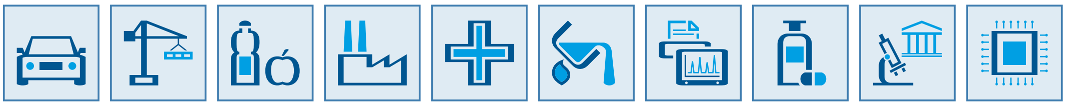
Proposed by the Industry
Signal word: WARNING

H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; **Refrigerated Gas → H281 –** Contains refrigerated gas; may cause cryogenic burns or injury; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 1A (Compressed)
3A (Refrigerated liquid)

DOT Class 2.2


AUTO CONSTR FOOD MANUF MEDICAL METAL OEM PHARMA R&D SEMI

Source

The most common source of argon is an air separation plant. Air contains approx. 0.93% (vol.) argon. A crude argon stream containing up to 5% oxygen is removed from the main air separation column via a secondary ("side-arm") column. The crude argon is then further purified to produce the various commercial grades required. Argon may also be recovered from the exhaust streams of certain ammonia plants.

Applications

Argon is one of the most common carrier gases in gas chromatography. Argon is used as a carrier gas in sputtering, plasma etching and ion implantations, and as a blanket atmosphere in crystal growth.

Argon is also the choice gas for ICP spectroscopy (Inductively Coupled Plasma spectroscopy).

One of the most common applications of argon, either pure or in various mixtures, is as a shielding gas for arc welding.

Many Geiger-counting tubes contain argon or argon mixed with organic vapours or other gases, for example 10% methane in argon.

Argon is one of the principal gases used for filling incandescent (filament) lamps, generally in a mixture with nitrogen, krypton or neon, for phosphorescent tubes in mixtures with neon, helium and mercury vapour and for thyratron radio tubes, in mixtures with neon.

The argon-oxygen decarburising (AOD) process is the most common method of refining stainless steel, and uses large quantities of both gases supplied either in liquid form or via pipeline from an on-site plant.

The pharmaceutical industry uses argon to displace oxygen in the top of intravenous drug containers, extending product shelf-life

Liquid argon is used in cryosurgery, e.g. cryoablation to destroy cancer cells.

Argon, R-740, is used in gas mixtures for non-CFC ultra-low temperature refrigeration applications.

Argon:

- → is used in atomic absorption spectrometry as a blanket gas in the graphite furnace.
- → is used in blends with, for example, fluorine and helium in excimer lasers.
- → is used as an insulation gas in high-efficiency multi-pane windows to improve thermal insulation.
- → is used in the iron and steel industry to prevent oxidation of molten metals and alloys and for degassing and desulphurization of molten steel and iron baths.
- → is used, often in a mixture with hydrogen, as a protective atmosphere for the heat treatment of certain metals, particularly those which are susceptible to nitriding when treated in a nitrogen-based atmosphere. This includes stainless steels and many different specialised and therefore small-scale applications.
- → is used for wine preservation to eliminate air by the heavier argon, to prevent oxidation and extend the product quality for opened bottles and barrels.
- → is, sometimes in combination with nitrogen, used to inflate airbags.
- → is used, often in combination with nitrogen and/or carbon dioxide, as a clean fire extinguishing gas, since the inert properties do not damage any materials extinguished.
- → is used in laboratory as purge gas or balance gas in gas mixtures.

Physical data

Molecular weight		39.948		
Boiling point	at 1.013 bar [°C]	−185.87	at 14.5 psi [°F]	−352.55
Density	at 1.013 bar, 15 °C [kg/m³]	1.691	at 1 atm., 70 °F [lb/ft³]	0.103
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Arsine AsH_3

CAS: 7784-42-1
EC: 232-066-3
UN: 2188

Purity grade	Typical purity	Typical impurities [ppm]						
		O_2	N_2	CO	CO_2	C_nH_m	H_2O	PH_3
HiQ® Arsine 5.0	≥99.999 %	≤1	≤3	≤1	≤1	≤1	≤2	≤0.1

Typical filling pressure: 15 °C: 13.5 bar(a)/70 °F: 204.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Toxic substance is formed with combustion. Colourless, liquefied gas with garlic-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H330 – Fatal if inhaled; H373 – May cause damage to upper and lower respiratory tract through prolonged or repeated inhalation; H410 – Very toxic to aquatic life with long lasting effects.

Transport of dangerous goods

ADR Class 2, 2TF

DOT Class 2.3

R&D SEMI

Source

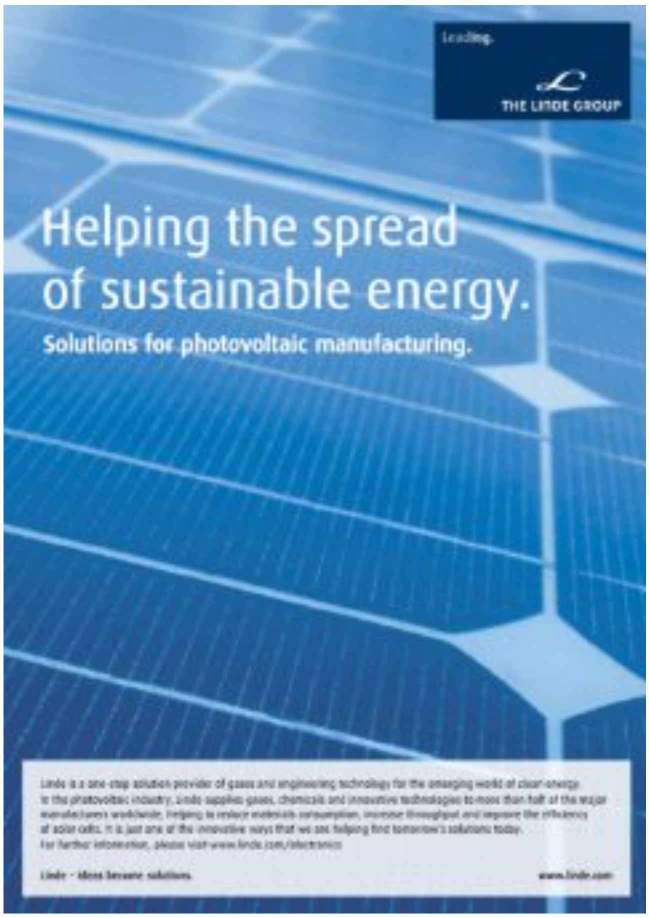
Arsine is commercially produced by the reaction of zinc arsenide and sulfuric acid. The crude arsine produced by this reaction is purified by a combination of distillation and catalytic absorption of the impurities.

Applications

Arsine is used in conjunction with organometallic compounds and as carrier gas in the epitaxical growth of compound semiconductors. In a Chemical Vapour Deposition (CVD) arsine reacts with trimethyl gallium to produce gallium arsenide (GaAs). It is also used for n-type doping of silicon-based semiconductors.

Arsine is commonly used in the production of solar cells, in MOCVD (Metal Organic Chemical Vapour Deposition) applications.

Arsine is also used in the production of electroluminescent diodes.



Physical data

Molecular weight		77.945		
Boiling point	at 1.013 bar [°C]	–62.48	at 14.5 psi [°F]	–80.44
Density	at 1.013 bar, 15 °C [kg/m^3]	3.334	at 1 atm., 70 °F [lb/ft^3]	0.204
Vapour pressure	at 0 °C [bar]	9.02	at 32 °F [psi]	130.9
	at 20 °C [bar]	14.74	at 70 °F [psi]	219.32
Flammability range in air [% volume]		3.9 – 77.8		

Boron trichloride BCl_3

CAS: 10294-34-5
EC: 233-658-4
UN: 1741

Purity grade	Typical purity	Typical impurities [ppm]							
		O_2	N_2	CO	CO_2	C_nH_m	Fe	Cl_2	phosgene
HiQ® Boron trichloride 3.0	≥99.9 %	-	-	-	-	-	-	≤100 %(w)	≤200 %(w)
HiQ® Boron trichloride 4.0	≥99.99 %	≤5	≤50	≤5	≤50	≤5	-	-	-
HiQ® Boron trichloride 5.0	≥99.999 %	≤1	≤2	≤1	≤5	≤1	≤0.2 %(w)	-	-

Typical filling pressure: 15 °C: 1.1 bar(a)/70 °F: 5.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Liquefied gas, decomposes in water to hydrogen chloride and boric acid. Forms white fumes in humid air. Pungent odour. Highly corrosive. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

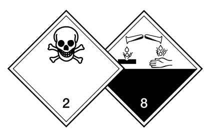
GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EUH014 – Reacts violently with water; H330 – Fatal if inhaled; H300 – Fatal if swallowed; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM MANUF METAL PETRO PHARMA R&D SEMI

Source

Boron trichloride is produced by reacting together one of the following sets of ingredients. In each case the reaction requires elevated temperatures:

a. industrially produced in a direct reaction of carbon, boron oxide and chlorine at 500°C
b. boric oxide plus the chloride of either sodium, potassium or lithium
c. sodium boronfluoride plus magnesium chloride
d. boron carbide plus chlorine.

Applications

Boron trichloride is used as a chemical reagent in the pharmaceutical industry.

Boron trichloride is used as a source of boron for p-type doping of silicon by thermal diffusion or ion implantation. It is also used for dry plasma etching of aluminium and its alloys.

Boron trichloride is used in refining metals such as aluminium, magnesium, zinc and copper alloys. By bubbling the gas through these molten metal nitrides, carbides and oxides are removed. The same technique is used to clean up castings of these metals. In this case occluded gases such as nitrogen, hydrogen and carbon monoxide are also removed from the casting.

Boron trichloride may be used in the production of optical fibres.

Boron trichloride is the starting material for the production of boron nitride, used as a refractory coating on such articles as crucibles etc.

Boron trichloride is used as a carrier gas, as a catalyst in organic reactions, and for manufacturing of electrical resistors.

Boron trichloride is also used as a starting material in the generation of elemental boron.

Boron trichloride is also used as a chemical in plasma etching of metals, such as stainless steel, copper alloys, and tungsten.

Boron trichloride plays a role in the manufacture of high energy fuels and rocket propellants to raise the Gross Calorific Value.

Physical data

Molecular weight		117.17		
Boiling point	at 1.013 bar [°C]	12.5	at 14.5 psi [°F]	54.52
Density	at 1.013 bar, 15 °C [kg/m^3]	5.162	at 1 atm., 70 °F [lb/ft^3]	0.315
Vapour pressure	at 0 °C [bar]	0.63	at 32 °F [psi]	9.09
	at 20 °C [bar]	1.33	at 70 °F [psi]	19.91
Flammability range in air [% volume]		Non combustible		

Boron trifluoride BF_3

CAS: 7637-07-2
EC: 231-569-5
UN: 1008

Purity grade	Typical purity	Typical impurities [ppm]		
		SiF_4	$O_2 + N_2$	$SO_2 + SO_3$
HiQ® Boron trifluoride 2.5	≥99.5 %	≤1,000	≤4,000	≤200

Typical filling pressure: 15 °C: 60 bar(a)/70 °F: 855.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Pungent odour. Highly corrosive. Forms white fumes in humid air. Gas density is heavier than air.

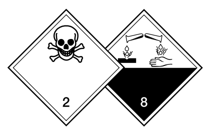
Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **EUH014** – Reacts violently with water; **H330** – Fatal if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract; **H373** – May cause damage to kidney through prolonged or repeated inhalation.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM METAL PETRO PHARMA R&D SEMI

Source

Boron trifluoride is prepared by the reaction of a boron-containing material with a fluorine-containing substance in the presence of an acid. The traditional method uses borax, fluorspar and sulfuric acid.

Another process for manufacturing boron trifluoride is to treat fluorosulfonic acid with boric acid.

Applications

Boron trifluoride is used as a catalyst in organic synthesis for: isomerisation, alkylation, polymerisation, esterification, halogenation, sulfonation, condensation and nitration.

Boron trifluoride is used as a catalyst in the Friedel-Crafts-type reaction, in the synthesis of saturated hydrocarbons, olefins and alcohols.

Boron trifluoride is used as a protective atmosphere for molten magnesium.

Boron trifluoride initiates polymerisation reactions of unsaturated compounds such as polyethers.

Boron trifluoride is also used as a dopant in ion implantation. In the semiconductor industry, the boron atom functions as a p-type dopant in epitaxially grown silicone.

Other niche uses are found in fumigation, in soldering magnesium, in the production of diborane or in ionisation chambers as a sensitive neutron detector.

Physical data

Molecular weight		67.806		
Boiling point	at 1.013 bar [°C]	−99.8	at 14.5 psi [°F]	−147.62
Density	at 1.013 bar, 15 °C [kg/m³]	2.882	at 1 atm., 70 °F [lb/ft³]	0.176
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Bromoethylene C_2H_3Br

Bromoethene, Vinyl bromide

CAS: 593-60-2
EC: 209-800-6
UN: 1085

Purity grade	Typical purity	Typical impurities [ppm]
Bromoethene	on request	contact local team

Typical filling pressure: 15 °C: 1 bar(a)/70 °F: -0.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, colourless gas with an ethereal odour. Stable, but may polymerise in sunlight. Reacts violently with all types of oxidiser. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → **H280 –** Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas; **H350 –** May cause cancer; **H231 –** May react explosively even in absence of air at elevated pressure and/or temperature.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM FOOD MANUF METAL PETRO PHARMA R&D

Source

Bromoethylene is produced in a reaction of acetylene, hydrogen bromide and higher brominated compounds in the presence of a contact catalyst.

Other generation routes are

- distilling a mixture of hydrogen bromide, ethyl alcohol and sulfuric acid, with the phosphorus and bromine method.
- refluxing ethanol with hydrobromic acid, or with an alkali bromide and sulfuric acid.

Applications

Bromoethylene is used in the production of polymers and co-polymers.

Bromoethylene is used in the production of leather.

Bromoethylene is used in the production of fabricated metal products.

Bromoethylene is used in the production of pharmaceuticals.

Bromoethylene is used in the production of fumigants.

Bromoethylene can be used as a flame retardant and to produce flame retardant synthetic fibres.

Bromoethylene is used to manufacture bromopolymers, mainly polybromoethene.

Bromoethylene is used in organic synthesis as an alkylation agent.

Physical data

Molecular weight		106.95		
Boiling point	at 1.013 bar [°C]	15.8	at 14.5 psi [°F]	60.46
Density	at 1.013 bar, 15 °C [kg/m^3]	4.653	at 1 atm., 70 °F [lb/ft^3]	0.284
Vapour pressure	at 0 °C [bar]	0.56	at 32 °F [psi]	8.13
	at 20 °C [bar]	1.18	at 70 °F [psi]	17.74
Flammability range in air [% volume]		5.6 – 13.5		

1,3-Butadiene C_4H_6

CAS: 106-99-0
EC: 203-450-8
UN: 1010

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
HiQ® 1,3-butadiene 2.5	≥99.5 %	≤5,000

Typical filling pressure: 15 °C: 2 bar(a)/70 °F: 22 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics
Flammable. Liquefied, colourless gas. Can form explosive peroxides in air. The cylinder contains an inhibitor to prevent polymerisation. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: **DANGER**

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas; **H350 –** May cause cancer; **H340 –** May cause genetic defects.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO R&D

Source

1,3-Butadiene is manufactured by steam cracking of naphtha or gas oil fractions.

1,3-Butadiene is also produced by catalytic dehydrogenation of n-butene and n-butane, and by oxidative dehydrogenation of n-butene.

The butadiene-containing C4-fractions obtained in these processes are then further separated. While C4-fractions readily form azeotropes, butadiene is isolated by using liquid-liquid extraction or extractive distillation.

Applications

1,3-Butadiene has been widely used in the manufacture of synthetic rubber.

1,3-Butadiene is finding increasing usage in the resins and plastic fields. Copolymers containing a high percentage of styrene have been widely used as reinforcing and stiffening resin for rubber, as water- and solvent-based paints, and in combinations with polystyrene for high impact plastics. Mixtures of styrene-acrylonitrile resins and butadiene-acrylonitrile rubbers have produced exceptionally high impact plastics having good chemical and heat distortion properties. 1,3-Butadiene is also used in the nylon production process to create one of the intermediates.

1,3-Butadiene is useful in a variety of miscellaneous organic reactions. It is particularly useful in the Diels-Alder reaction where it combines with activated olefins to give cyclic compounds.

1,3-Butadiene is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight		54.092		
Boiling point	at 1.013 bar [°C]	−4.41	at 14.5 psi [°F]	24.08
Density	at 1.013 bar, 15 °C [kg/m^3]	2.359	at 1 atm., 70 °F [lb/ft^3]	0.144
Vapour pressure	at 0 °C [bar]	1.2	at 32 °F [psi]	17.43
	at 20 °C [bar]	2.40	at 70 °F [psi]	36.07
Flammability range in air [% volume]		1.4 – 16.3		

n-Butane C_4H_{10}

R-600

CAS: 106-97-8
EC: 203-448-7
UN: 1011
R-600

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
n-Butane 2.5	≥99.5 %	≤5,000
HiQ® n-Butane 3.5	≥99.95 %	≤500

Typical filling pressure: 15 °C: 1.8 bar(a)/70 °F: 16.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

AUTO CHEM CONSTR ENERGY MANUF OEM PETRO R&D

Source

Both n-butane and iso-butane are extracted from natural gas or refinery gases. Extraction is performed by absorbing at high pressure in suitable absorber oils followed by a fractionation to remove other hydrocarbons like propane and pentanes. The two butanes are then separated by distillation.

Applications

n-Butane is primarily used as a heating and cooking fuel.

n-Butane finds widespread use as a motor fuel, e.g. for forklifts, especially under conditions where conventional fuel exhausts would not be desirable like the inside of buildings.

n-Butane is used to fill the thermobulbs in pressure and temperature gauges.

n-Butane is used as a chemical intermediate in the manufacture of a variety of organic chemicals:

- acetic acid
- butadiene, used as a raw material for the production of synthetic rubbers
- butenes employed for the production of butadienes, butanol, maleic anhydride and polybutenes
- ethene
- propylene

n-Butane is used as a component in calibration gases for the gas, oil and chemical industries.

It is also used as a standard fuel gas for the calibration of burners.

Very pure forms of n-Butane can be used in refrigeration applications, replacing ozone depleting halocarbons. It has the ASHRAE number R-600.

n-Butane is also used as an aerosol propellant, either pure or mixed with other hydrocarbons.

n-Butane/helium mixtures are used in ionising particle counters.

n-Butane and iso-butane, pure or as blends, are used as foam blowing agents.

Physical data

Molecular weight		58.123		
Boiling point	at 1.013 bar [°C]	−0.5	at 14.5 psi [°F]	31.12
Density	at 1.013 bar, 15 °C [kg/m³]	2.547	at 1 atm., 70 °F [lb/ft³]	0.155
Vapour pressure	at 0 °C [bar]	1.04	at 32 °F [psi]	15.02
	at 20 °C [bar]	2.08	at 70 °F [psi]	31.29
Flammability range in air [% volume]		1.4 – 9.4		

iso-Butane C_4H_{10}

Methylpropane, R-600a

CAS: 75-28-5
EC: 200-857-2
UN: 1969
R-600a

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
iso-Butane 1.8	≥98 %	-
iso-Butane 2.5	≥99.5 %	≤5,000
HiQ® iso-Butane 3.5	≥99.95 %	≤500

Typical filling pressure: 15 °C: 2.6 bar(a)/70 °F: 31 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

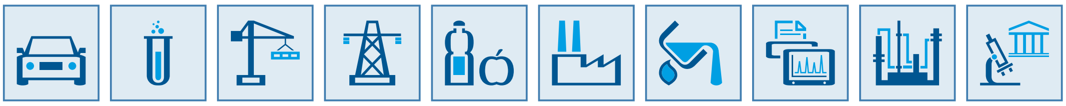
H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1



Source

Both n-butane and iso-butane are extracted from natural gas or refinery gases. Extraction is performed by absorbing at high pressure in suitable absorber oils followed by a fractionation to remove other hydrocarbons like propane and pentanes. The two butanes are then separated by distillation.

Applications

iso-Butane is primarily used as a heating fuel, not only in private homes, but also in agriculture, for farming and farm processing, as well as in hotels, restaurants and holiday resorts.

Industrial grade butane is a mixture of n-butane and iso-butane.

iso-Butane is used industrially as a fuel in the metallurgical, glass and ceramic industries as well as an intermediate in the manufacture of aviation fuel.

iso-Butane is a common refrigerant in domestic refrigerators. It has the ASHRAE number R-600a.

Mixed with propane, it is used as a refrigerant in water coolers, beer coolers and in domestic refrigerators. It is also used in small proportions in some HFC refrigerant blends for industrial and commercial refrigeration and air conditioning applications.

Mixed with propane, butane is also used as a fuel for internal combustion engines, e.g. in forklifts.

iso-Butane is used as a component in calibration gases for the gas, oil and chemical industries.

iso-Butane is used as a chemical intermediate in the manufacture of a variety of organic chemicals:

- → acetic acid
- → butadiene, used as a raw material for the production of synthetic rubbers
- → iso-butene used for the production of isoprene/polyisoprene, methacrylonitrile, polyisobutene and butyl rubber
- → ethene
- → propylene

iso-Butane finds use as an aerosol propellant, alone or mixed with other hydrocarbons.

iso-Butane is also used to fill thermometer bulbs and for saturated vapour pressure type pressure gauges.

iso-Butane/helium mixtures are used in ionising particle counters. iso-Butane is also used in nuclear research for multi-wire proportional scintillation chambers and other particle detectors.

n-Butane and iso-Butane are used pure or in mixtures for foam blowing.

Physical data

Molecular weight		58.123		
Boiling point	at 1.013 bar [°C]	−11.72	at 14.5 psi [°F]	10.92
Density	at 1.013 bar, 15 °C [kg/m^3]	2.537	at 1 atm., 70 °F [lb/ft^3]	0.155
Vapour pressure	at 0 °C [bar]	1.59	at 32 °F [psi]	23.1
	at 20 °C [bar]	3.06	at 70 °F [psi]	45.8
Flammability range in air [% volume]		1.5 – 9.4		

1-Butene C_4H_8

Bute-1-ene , Butene-1 , a-Butylene

CAS: 106-98-9
EC: 203-449-2
UN: 1012

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
HiQ® 1-butene 2.5	≥99.5 %	≤5,000

Typical filling pressure: 15 °C: 2.2 bar(a)/70 °F: 23.5 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO R&D

Source

1-Butene is produced by thermal or catalytic cracking of petroleum as well as by catalytic dehydrogenation of butane or dimerisation of ethylene.

1-Butene is produced either by separation from crude C4 refinery streams or from the dimerisation of ethylene. It is distilled to give a high-purity product.

Applications

1-Butene is an intermediate in the preparation of a variety of chemicals, such as detergents, plastics and synthetic rubbers, linear low-density polyethylene (LLDPE), polypropylene resins, polybutene, butylene oxide and butanone.

1-Butene is used as an intermediate in preparing organic compounds like in the industrially important Oxo process, with alkenes reacting catalytically with carbon monoxide and hydrogen to give aldehydes.

In the fuel industry, alkenes are polymerised by heating with catalysts to give high-octane gasolines.

1-Butene is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight		56.107		
Boiling point	at 1.013 bar [°C]	−6.25	at 14.5 psi [°F]	20.77
Density	at 1.013 bar, 15 °C [kg/m^3]	2.449	at 1 atm., 70 °F [lb/ft^3]	0.149
Vapour pressure	at 0 °C [bar]	1.29	at 32 °F [psi]	18.64
	at 20 °C [bar]	2.57	at 70 °F [psi]	38.58
Flammability range in air [% volume]		1.2 – 10.6		

cis-2-Butene C_4H_8

CAS: 590-18-1
EC: 209-673-7
UN: 1012

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
HiQ® cis-2-Butene 2.0	≥99 %	≤10,000

Typical filling pressure: 15 °C: 1.5 bar(a)/70 °F: 13 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics
Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: **DANGER**

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO R&D

Source

Almost all commercially produced butenes are obtained as by-products from two principal processes:

- catalytic or thermal cracking, refinery processes which upgrade high boiling petroleum fractions to gasoline,
- steam cracking, which produces light olefins for chemical feedstocks by pyrolysis of saturated hydrocarbons derived from natural gas or crude oil.

The butenes obtained are withdrawn as a mixture from the C4 fraction. From this mixture butadiene and butanes are separated by extractive distillation. The remaining butenes cannot be separated by mere distillation because their boiling points are too close together.

In a first step, iso-butene is isolated either by etherification with methanol to form methyl tert-butylether (MTBE), or by hydrating iso-butene to tert-butanol (TBA). In this step, all other C4 components in the mixture remain unchanged. MTBE and TBA can then be split by reversing synthesis to produce high purity iso-butene.

Once the iso-butene content has been reduced, recovery of high purity 1-butene is possible by fractionation. The remaining 2-butenes can be separated by molecular sieve absorption methods.

Other commercial processes that are sometimes used to produce specific isomers or mixtures of butenes or both, either directly or as by-products, include:

- the oxirane process for making propylene oxide (-> iso-butene)
- the dehydrogenation of butane and iso-butane (-> 1-butene, cis-2-butene, trans-2-butene)
- the disproportionation of olefins (-> cis-2-butene, trans-2-butene)
- the oligomerisation of ethylene (-> 1-butene).

All or any of them may become useful feedstock sources should the need arise.

Applications

cis-2-Butene is a chemical intermediate in the following processes:

- catalytic dehydrogenation to produce butadiene
- the addition of water by means of the acid sulfate leads to the formation of 2-butanol
- esterification in the presence of tungstic acid, followed by oxidation by oxygen or air, in the liquid phase, leads to the production of acetic acid
- acetic acid can also be produced through oxidation by oxygen or air in the presence of manganese acetate in the liquid phase
- condensation of iso-butane with butenes leads to the formation of 2,2,3-trimethyl pentane, a high octane fuel.

cis-2-Butene is a member of the alkene group of hydrocarbons. Alkenes serve as intermediates in the preparation of a variety of organic compounds. Sulfuric acid and sulfur dioxide react with alkenes to give alkyl hydrogen sulfates and alkyl sulfonates, respectively, many of which are useful as detergents. In the industrially important oxo process, alkenes react catalytically with carbon monoxide and hydrogen to give aldehydes. Alkenes are polymerised by heating with catalysts to give high-octane gasolines, plastics and synthetic rubber. Alkanes react with alkenes in the presence of catalysts to form motor fuels in a process known as alkylation.

cis-2-Butene is used as a component in calibration gases.

Physical data

Molecular weight		56.107		
Boiling point	at 1.013 bar [°C]	3.72	at 14.5 psi [°F]	38.72
Density	at 1.013 bar, 15 °C [kg/m^3]	2.457	at 1 atm., 70 °F [lb/ft^3]	0.150
Vapour pressure	at 0 °C [bar]	0.88	at 32 °F [psi]	12.75
	at 20 °C [bar]	1.81	at 70 °F [psi]	27.26
Flammability range in air [% volume]		1.6 – 10.0		

iso-Butene C_4H_8

Isobutylene , 2-Methylpropane

CAS: 115-11-7
EC: 204-066-3
UN: 1012

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
HiQ® iso-Butene 3.0	≥99.9 %	≤1,000

Typical filling pressure: 15 °C: 2.3 bar(a)/70 °F: 24 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO R&D

Source

Almost all commercially produced butenes are obtained as by-products from two main processes:

- catalytic or thermal cracking, refinery processes which upgrade high boiling petroleum fractions to gasoline,
- steam cracking, which produces light olefins for chemical feedstocks by pyrolysis of saturated hydrocarbons derived from natural gas or crude oil.

The butenes obtained are withdrawn as a mixture from the C4 fraction. From this mixture butadiene and butanes are separated by extractive distillation. The remaining butenes cannot be separated by mere distillation because their boiling points are too close together.

In a first step, iso-butene is isolated either by etherification with methanol to form methyl tert-butylether (MTBE), or by hydrating iso-butene to tert-butanol (TBA). In this step, all other C4 components in the mixture remain unchanged. MTBE and TBA can then be split by reversing synthesis to produce high purity iso-butene.

Once the iso-butene content has been reduced, recovery of high purity 1-butene is possible by fractionation. The remaining 2-butenes can be separated by molecular sieve absorption methods.

Other commercial processes that are sometimes used to produce specific isomers or mixtures of butenes or both, either directly or as by-products, include:

- the oxirane process for making propylene oxide (-> iso-butene)
- the dehydrogenation of butane and iso-butane (-> 1-butene, cis-2-butene, trans-2-butene)
- the disproportionation of olefins (-> cis-2-butene, trans-2-butene)
- the oligomerisation of ethylene (-> 1-butene).

All or any of them may become useful feedstock sources should the need arise.

cis- and trans 2-Butene show very similar reactivity in most of the desired chemical reactions.

Applications

iso-Butene is mainly used as a chemical intermediate.

iso-Butene reacts with methanol and ethanol, producing the gasoline oxygenates methyl tert-butyl ether (MTBE) and ethyl tert-butyl ether (ETBE). Alkylation with butane produces isooctane, another fuel additive.

iso-Butene is also used in the production of methacrolein.

Polymerisation of iso-Butene produces butyl rubber (polyisobutylene) an acid- and alkaline-resistant rubber.

Antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are produced by Friedel-Crafts alkylation of phenols using isobutylene.

iso-Butene is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight		56.107		
Boiling point	at 1.013 bar [°C]	−6.89	at 14.5 psi [°F]	19.62
Density	at 1.013 bar, 15 °C [kg/m^3]	2.448	at 1 atm., 70 °F [lb/ft^3]	0.149
Vapour pressure	at 0 °C [bar]	1.33	at 32 °F [psi]	19.35
	at 20 °C [bar]	2.64	at 70 °F [psi]	39.59
Flammability range in air [% volume]		1.6 – 10.0		

trans-2-Butene C_4H_8

CAS: 624-64-6
EC: 210-855-3
UN: 1012

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
HiQ® trans-2-Butene 2.0	≥99 %	≤10,000

Typical filling pressure: 15 °C: 1.7 bar(a)/70 °F: 15 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics
Flammable, liquefied, colourless gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: **DANGER**

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO R&D

Source

Almost all commercially produced butenes are obtained as by-products from two principal processes:

- catalytic or thermal cracking, refinery processes which upgrade high boiling petroleum fractions to gasoline,
- steam cracking, which produces light olefins for chemical feedstocks by pyrolysis of saturated hydrocarbons derived from natural gas or crude oil.

The butenes obtained are withdrawn as a mixture from the C4 fraction. From this mixture butadiene and butanes are separated by extractive distillation. The remaining butenes cannot be separated by mere distillation because their boiling points are too close together.

In a first step, iso-butene is isolated either by etherification with methanol to form methyl tert-butylether (MTBE), or by hydrating iso-butene to tert-butanol (TBA). In this step, all other C4 components in the mixture remain unchanged. MTBE and TBA can then be split by reversing synthesis to produce high purity iso-butene.

Once the iso-butene content has been reduced, recovery of high purity 1-butene is possible by fractionation. The remaining 2-butenes can be separated by molecular sieve absorption methods.

Other commercial processes that are sometimes used to produce specific isomers or mixtures of butenes or both, either directly or as by-products, include:

- the oxirane process for making propylene oxide (-> iso-butene)
- the dehydrogenation of butane and iso-butane (-> 1-butene, cis-2-butene, trans-2-butene)
- the disproportionation of olefins (-> cis-2-butene, trans-2-butene)
- the oligomerisation of ethylene (-> 1-butene).

All or any of them may become useful feedstock sources should the need arise.

cis- and trans 2-Butene show very similar reactivity in most of the desired chemical reactions.

Applications

trans-2-Butene is employed as a chemical intermediate in the following processes:

- catalytic dehydrogenation that produces butadiene
- the addition of water by means of the acid sulfate leads to the formation of 2-butanol
- esterification in the presence of tungstic acid, followed by oxidation by oxygen or air in the liquid phase, leads to the production of acetic acid
- acetic acids can also be produced through oxidation by oxygen or air in the presence of manganese acetate, in the liquid phase.

trans-2-Butene is a member of the alkene group of hydrocarbons. Alkenes serve as intermediates in the preparation of a variety of organic compounds. Sulfuric acid and sulfur dioxide react with alkenes to give alkyl hydrogen sulfates and alkyl sulfonates, respectively, many of which are useful detergents. In the industrially important oxo process, alkenes react catalytically with carbon monoxide and hydrogen to give high octane gasolines, plastics and synthetic rubber. Alkanes react with alkenes in the presence of catalysts to form motor fuels in a process known as alkylation.

trans-2-Butene is used as a component in calibration gases for the gas, oil and chemical industries.

trans-2-Butene is also employed as a solvent.

Physical data

Molecular weight		56.107		
Boiling point	at 1.013 bar [°C]	0.88	at 14.5 psi [°F]	33.60
Density	at 1.013 bar, 15 °C [kg/m^3]	2.455	at 1 atm., 70 °F [lb/ft^3]	0.150
Vapour pressure	at 0 °C [bar]	0.98	at 32 °F [psi]	14.21
	at 20 °C [bar]	1.99	at 70 °F [psi]	29.94
Flammability range in air [% volume]		1.6 – 10.0		

1-Butyne C_4H_6

Ethylacetylene

CAS: 107-00-6
EC: 203-451-3
UN: 2452

Purity grade	Typical purity	Typical impurities [ppm]
1-Butyne	on request	contact local team

Typical filling pressure: 15 °C: 2.3 bar(a)/70 °F: 9.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable, liquefied, colourless gas with garlic-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H231** – May react explosively even in absence of air at elevated pressure and/or temperature.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO R&D

Source

Propyne is produced industrially by thermal cracking of hydrocarbons.

1-Butyne is also prepared by reacting sodium acetylide with diethyl sulfate.

It may also be obtained by treating 1,2- or 1,1-dibromobutane with alcoholic caustic alkali.

Applications

1-Butyne is used as a component in calibration gases for the gas, oil and chemical industries.

1-Butyne is commonly used in the synthesis of organic materials.

Physical data

Molecular weight		54.090		
Boiling point	at 1.013 bar [°C]	8.1	at 14.5 psi [°F]	46.58
Density	at 1.013 bar, 15 °C [kg/m³]	2.29	at 1 atm., 70 °F [lb/ft³]	0.143
Vapour pressure	at 0 °C [bar]	0.73	at 32 °F [psi]	10.59
	at 20 °C [bar]	1.58	at 70 °F [psi]	23.88
Flammability range in air [% volume]		1.3 – not defined		

Carbon dioxide CO_2

R-744

CAS: 124-38-9
EC: 204-696-9
UN: 1013
UN: 2187 (Refrigerated liquid)
R-744

Purity grade	Purity	Impurities [ppm]														
		H_2O	O_2	N_2	CO	NH_3	NO_x	H_2S	SO_2	O_2+N_2	C_nH_m	C_nH_m (as CH_4)	C_nH_m (as $C_{16}H_{34}$)	Total Sulfur	Non-volatile residue	Halocarbons
HiQ® Carbon dioxide 4.0	≥99.99 %	≤10	≤10	≤50	-	-	-	-	-	-	-	-	-	-	-	-
HiQ® Carbon dioxide 4.5	≥99.995 %	≤5	≤5	≤10	-	-	-	-	-	-	≤2	-	-	-	-	-
HiQ® Carbon dioxide 4.5 SFC	≥99.995 %	≤1	≤5	-	-	-	-	-	-	-	-	≤5	≤50 ppb	-	≤1	≤10 ppb
HiQ® Carbon dioxide 5.0	≥99.999 %	≤2	≤2	≤5	≤1	-	-	-	-	-	≤1	-	-	-	-	-
HiQ® Carbon dioxide 5.0 SFE	≥99.999 %	≤1	≤2	-	-	-	-	-	-	-	-	≤1	≤10 ppb	-	≤1	≤2 ppb
VERISEQ® Process Carbon dioxide (pharmaceutical grade)	≥99.5 %	≤67	-	-	≤5	≤25	≤2	≤1	≤2	-	-	-	-	≤1	-	-
VERISEQ® Research Carbon dioxide (pharmaceutical grade)	≥99.99 %	≤10	-	-	≤5	≤25	≤2	≤1	≤2	≤50	-	-	-	≤1	-	-

Typical filling pressure: 15 °C: 51 bar(a)/70 °F: 830 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				•

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Liquefied, colourless gas. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

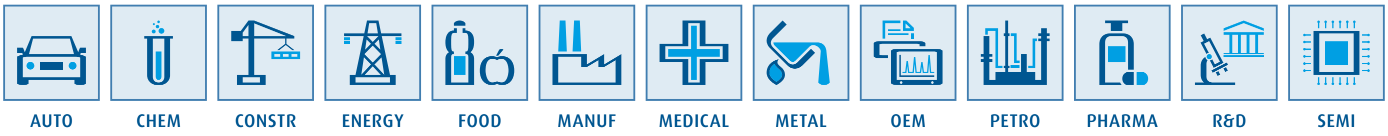
Proposed by the Industry
Signal word: WARNING

H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigereted Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A
3A (Refrigerated liquid)

DOT Class 2.2



Source

Carbon dioxide is recovered from many different sources. It is obtained as an off-gas from fermentation processes, lime-stone kilns, natural CO_2 springs, as well as gas streams from chemical and petrochemical operations. Recently, CO_2 is also recaptured from the off-gas from power plants.

Applications

Carbon dioxide is used extensively as a neutralizing agent for pH control, for example, in cement curing water treatment and in many other commercially important chemical applications.

Carbon dioxide is used in many consumer products ranging from aerosol packaging to air guns that require pressurised gas because it is inexpensive and non-flammable; in the operation of pneumatic equipment and for the transfer of hazardous and flammable liquids.

Owing to its stimulating effect on the nerve centres, carbon dioxide is employed in medicine in mixtures with oxygen, for reanimating victims of asphyxiation. It also serves in the treatment of certain skin affections.

A substantial volume of carbon dioxide is used for carbonating beverages such as beer and many soft drinks and conservation of wine, unfermented grape juice and various fruit juices.

Carbon dioxide is used to modify atmospheres, for example in green houses where it increases plant growth rates or combined with nitrogen to prolong quality in food packaging applications (MAP – Modified Atmosphere Packaging).

Carbon dioxide, when mixed with helium and nitrogen, is used as the active medium in carbon dioxide lasers.

Carbon dioxide is used as an inerting agent for various mild steel welding operations, often in combination with argon.

Note:

Carbon dioxide is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Carbon dioxide is used as media for supercritical fluid extraction (SFE) in sample preparation and as a carrier gas for analytical and preparative supercritical fluid chromatography (SFC).

Liquid carbon dioxide is becoming increasingly used as a refrigerant in mechanical refrigerating systems due to its environmental credentials. It has the ASHRAE number R-744. "Dry ice", or solid CO_2 is commonly used for refrigeration.

Liquid/solid carbon dioxide is used for cooling gas chromatography ovens.

Possible refrigerant for MAC (Mobile Air Conditioning) due to European phase out of tetrafluoroethane (R-134a).

Carbon dioxide:

- → is used for the chemical vapour deposition of silicon dioxide.
- → is used for foam blowing.
- → is used in Coleman nitrogen analysers.
- → is used in mixtures for car emission monitoring and environmental monitoring.
- → is used for fire extinguishing.
- → is often used in combination with ethylene oxide for sterilizing purposes.
- → is also used for blood analysis and dehydration of penicillin.
- → is used for production of paints and varnishes.

Physical data

Molecular weight		44.01		
Boiling point	at 1.013 bar [°C]	−78.5	at 14.5 psi [°F]	−109.3
Density	at 1.013 bar, 15 °C [kg/m³]	1.872	at 1 atm., 70 °F [lb/ft³]	0.114
Vapour pressure	at 0 °C [bar]	34.5	at 32 °F [psi]	505.3
	at 20 °C [bar]	57.3	at 70 °F [psi]	853.7
Flammability range in air [% volume]		Non combustible		

Carbon monoxide CO

CAS: 630-08-0
EC: 211-128-3
UN: 1016

Purity grade	Typical purity	Typical impurities [ppm]						
		N_2	H_2	O_2	Ar	O_2 + Ar	C_nH_m	H_2O
Carbon monoxide 2.0	≥99 %	≤4,000	≤1,500	-	-	≤3,000	≤500	-
HiQ® Carbon monoxide 3.0	≥99.9 %	≤750	≤250	-	-	≤60	≤50	-
HiQ® Carbon monoxide 3.7	≥99.97 %	≤300	≤100	≤10	≤20	-	≤10	≤10
HiQ® Carbon monoxide 4.7	≥99.997 %	≤10	≤1	≤5	≤15	-	≤2	≤5

Typical filling pressure: 15 °C: 200 bar(a)/70 °F: 2,000 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•			•	

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Odourless and colourless gas. Gas density is heavier than air. Corrosion effects due to the simultaneous presence of carbon monoxide, traces of carbon dioxide and moisture.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
Compressed Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H360D** – May damage the unborn child / Repr. 1A; **H331** – Toxic if inhaled; **H372** – Causes damage to the earth though prolonged or repeated inhalation.

Transport of dangerous goods

ADR Class 2, 1TF

DOT Class 2.3

AUTO CHEM ENERGY MANUF MEDICAL METAL OEM PETRO R&D

Source

The most common carbon monoxide production plants are "reformers" in which natural gas and steam react to produce CO and hydrogen.

Another industrial source of carbon monoxide is producer gas, a mixture containing mostly carbon monoxide and nitrogen, formed by combustion of carbon in air at high temperature.

A third industrial source is "water gas", a mixture of hydrogen and carbon monoxide produced via the endothermic reaction of steam and carbon.

There are also many other production techniques such as incomplete combustion of natural gas and, for smaller quantities, the dehydration of formic acid using either sulfuric or phosphoric acid.

Applications

Carbon monoxide is largely used in the chemical industry to yield a wide variety of chemicals such as esters, ketones, aldehydes and glycols as well as phosgene, an important chemical intermediate. Usually, the carbon monoxide volumes needed at chemical production sites are so large that the gas is produced on-site, though occasionally supplies in tube trailers may be viable.

Some types of electronic components, such as reed relay switches, are encapsulated in a glass enclosure which is sealed by direct heating with a flame. In these cases, it is important that no water is produced in the flame as this would be sealed in the enclosure and lead to failure of the component. Hydrogen and hydrocarbon fuels are therefore not suitable and so carbon monoxide is used instead.

Carbon monoxide is used in large quantities in the primary metals industry in many different ways, e.g. as a chemical reducing agent for the recovery of metals from ores or in the purification of aluminium waste or in the manufacture of high purity powdered metals by thermal decomposition of their metal carbonyls.

Methanol is produced by the hydrogenation of carbon monoxide. In a related reaction, the hydrogenation of carbon monoxide yields liquid hydrocarbon fuels. This technology allows coal or biomass to be converted to diesel fuels.

Acetic acid is industrially produced in a catalytic reaction of carbon monoxide and methanol.

Carbon monoxide also serves for the production and regeneration of catalysts such as nickel carbonyl.

Carbon monoxide is also used in both organic and inorganic chemical synthesis.

Carbon monoxide is a component in gas mixtures for lung diffusion.

Carbon monoxide is a component in laser gas mixtures. Carbon monoxide is a component in calibration gas mixtures.

A necessity in the production of solar cells is super clean silicium, which is produced with the aid of carbon monoxide.

Physical data

Molecular weight		28.01		
Boiling point	at 1.013 bar [°C]	−191.45	at 14.5 psi [°F]	−312.59
Density	at 1.013 bar, 15 °C [kg/m^3]	1.185	at 1 atm., 70 °F [lb/ft^3]	0.072
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		10.9 – 76		

Carbonyl fluoride CF_2O

Carbon oxyfluoride

CAS: 353-50-4
EC: 206-534-2
UN: 2417

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Carbonyl fluoride 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 45.7 bar(a)/70 °F: 646.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Liquefied, colourless gas. Hygroscopic with pungent odour. Contact with combustible material may cause fire. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

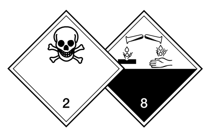
Proposed by the Industry

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM R&D

Source

Carbonyl fluoride is prepared by reacting carbon monoxide and fluorine, or carbon tetrafluoride and water at high temperature.

Oxidation of carbon monoxide with silver difluoride is commonly used.

Applications

Carbonyl fluoride is used as a fluorine source in laboratories.

Carbonyl fluoride is an important intermediate for the preparation of organic fluorine compounds.

Carbonyl fluoride is used as an etching gas in the semiconductor industry as well as a cleaning agent for chemical vapour deposition chambers.

Physical data

Molecular weight		66.01		
Boiling point	at 1.013 bar [°C]	–83	at 14.5 psi [°F]	–117
Density	at 1.013 bar, 15 °C [kg/m^3]	2.89	at 1 atm., 70 °F [lb/ft^3]	18.04
Vapour pressure	at 0 °C [bar]	30.66	at 32 °F [psi]	444.6
	at 20 °C [bar]	52.10	at 70 °F [psi]	777.8
Flammability range in air [% volume]		Non combustible		

Carbonyl sulfide COS

CAS: 463-58-1
EC: 207-340-0
UN: 2204

Purity grade	Typical purity	Typical impurities [ppm]
Carbonyl sulfide 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 9.6 bar(a)/70 °F: 124.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied gas with the odour of rotten eggs. Decomposes in water. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H331 – Toxic if inhaled.

Transport of dangerous goods

ADR Class 2, 2TF

DOT Class 2.3

AUTO CHEM ENERGY FOOD PHARMA R&D

Source

Carbonyl sulfide is formed by many high temperature reactions of carbon compounds with donors of oxygen and sulfur.

Another well-known synthetic procedure involves the reaction of a potassium thiocyanite solution with sulfuric acid followed by a purification process.

One patented method describes the manufacturing of carbonyl sulfide by the reaction of methanol with sulfur at 500–800°C.

Carbonyl sulfide occurs as a by-product in the manufacture of carbon disulfide. It is also known as an impurity in many manufactured fuel gases, in refinery gases and in combustion products of sulfur-containing fuels. You will find it as a contaminant in some natural gas sources. These COS traces may lead to unwanted corrosion in plant elements or cause poisoning of catalysts.

Applications

Carbonyl sulfide is particularly useful in the synthesis of thioacids, sulfur trisubstituted carbinols, substituted thiazoles and substituted thiocarbamic acids (salts). High yields are obtained in the synthesis of substituted thiazoles.

Carbonyl sulfide is gaining recognition in fumigation as a potential replacement for phosphine and methyl bromide.

In mixtures it is employed in the laboratory as a component in calibration gases for process control and environmental monitoring.

Carbonyl sulfide can be used as an odoriser for natural gas transport as well as for liquid petroleum gas (LPG).

Physical data

Molecular weight		60.076		
Boiling point	at 1.013 bar [°C]	−50.15	at 14.5 psi [°F]	−58.25
Density	at 1.013 bar, 15 °C [kg/m^3]	2.574	at 1 atm., 70 °F [lb/ft^3]	0.157
Vapour pressure	at 0 °C [bar]	6.0	at 32 °F [psi]	92.42
	at 20 °C [bar]	11.06	at 70 °F [psi]	164.96
Flammability range in air [% volume]		6.5 – 29.0		

Chlorine Cl_2

CAS: 7782-50-5
EC: 231-959-5
UN: 1017

Purity grade	Typical purity	Typical impurities [ppm]						
		H_2O	O_2	N_2	CO	CO_2	C_nH_m	Fe
Chlorine 2.8	≥99.8 %	contact local team						
HiQ® Chlorine 4.0	≥99.99 %	≤1	≤5	≤40	≤5	≤50	≤5	-
HiQ® Chlorine 5.0	≥99.999 %	≤1	≤1	≤2	≤1	≤5	≤1	≤0.5

Typical filling pressure: 15 °C: 5.9 bar(a)/70 °F: 85.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

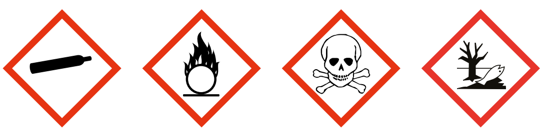
Yellowish-green liquefied gas with irritating odour. Corrosive. Heavy oxidizing agent. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

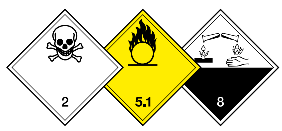
Signal word: DANGER



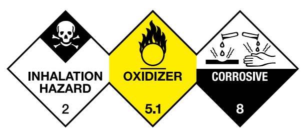
H-statements:

Liquefied gas → **H280** – Contains gas under pressure; may explode if heated; **H270** – May cause or intensify fire; oxidiser; **H330** – Fatal if inhaled; **H319** – Causes serious eye irritation; **EUH071** – Corrosive to the respiratory tract; **H315** – Causes skin irritation; **H400** – Very toxic to aquatic life.

Transport of dangerous goods



ADR Class 2, 2TOC



DOT Class 2.3

CHEM ENERGY MANUF METAL PETRO R&D SEMI

Source

Chlorine is produced commercially by the electrolysis of salt solutions (either sodium, potassium or magnesium chlorides). The production of chlorine is therefore usually accompanied by production of hydrogen.

Applications

Chlorine is used in relatively large quantities for the production of a wide variety of chemicals such as chloroethene, hydrochloric acid, carbon tetrachloride, trichloroethylene, etc. For many of these, which may themselves be only intermediates rather than end products, the chlorine may be produced on-site, with excess quantities being available for shipment into the merchant market.

High purity chlorine is used in the electronics industry for etching. It may also be used as an additive during other processes to keep surfaces clean, for example during oxidation process steps – hence preventing the incorporation of impurities in the oxidation layer.

Chlorine is used in the manufacture of fibre optics, phosgene and synthetic rubber.

Chlorine blended with argon is used for degassing molten aluminium. It is also used for the purification of gold and other precious metals.

As chlorine has the capability to bleach various materials, it is used in both the paper and textile industries for this purpose.

Chlorine is used for water purification in a variety of circumstances, including the "production" of drinking water by local water authorities, the treatment of swimming pools and waste water treatment by many types of industrial companies.

Chlorine may require registration/authorisation to comply with local legal requirements on biocidal products, such as those described in the Biocidal Products Regulation (No 528/2012) of the European Union.

Chlorine is used as component in gas mixtures.

Physical data

Molecular weight		70.905		
Boiling point	at 1.013 bar [°C]	−34.03	at 14.5 psi [°F]	−29.23
Density	at 1.013 bar, 15 °C [kg/m³]	3.042	at 1 atm., 70 °F [lb/ft³]	0.186
Vapour pressure	at 0 °C [bar]	3.70	at 32 °F [psi]	53.61
	at 20 °C [bar]	6.80	at 70 °F [psi]	101.64
Flammability range in air [% volume]		Non combustible		

1-Chloro-1,2,2,2-tetrafluoroethane C_2HClF_4

HCFC-124, R-124

CAS: 2837-89-0
EC: 220-629-6
UN: 1021
R-124

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
1-Chloro-1,2,2,2-tetrafluoroethane	≥99.8 %	≤20 ppm(w)

Typical filling pressure: 21.1 °C: 0.23 bar(a)/70 °F: 47.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless liquified gas with a slight ether-like smell. Stable at normal temperatures and storage conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: WARNING

H-statements:
H280 - Contains gas under pressure; may explode if heated; H420 - Harms public health and the environment by destroying ozone in the upper atmosphere.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

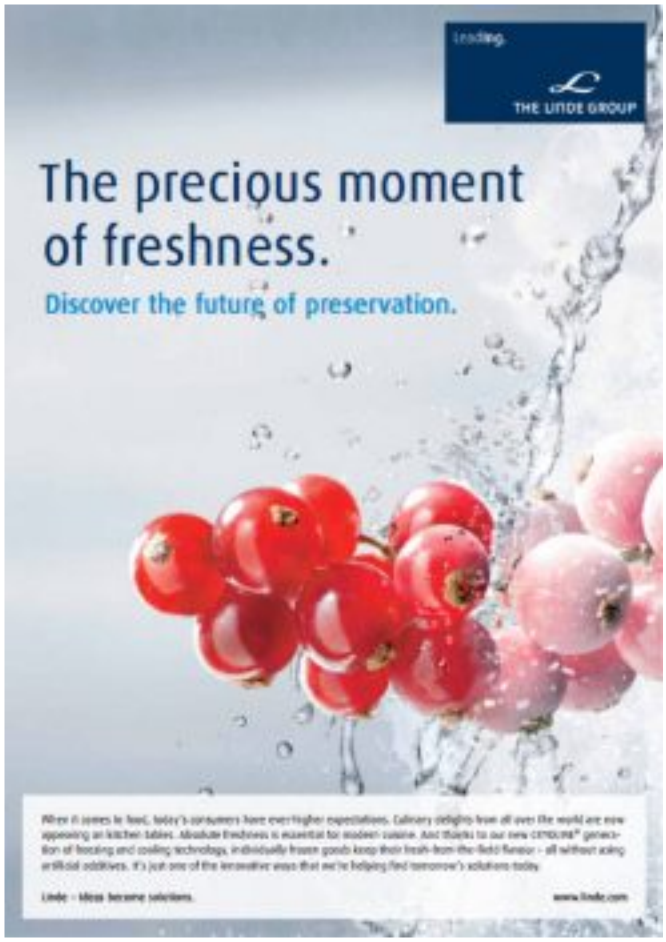
CHEM CONSTR FOOD PETRO

Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. Many synthesis routes for 2-chloro-1,1,1,2-tetrafluoroethane use trichloroethylene and/or tetrachloroethylene (also known as perchloroethylene, PCE), which is reacted with HF, often in the presence of a catalyst.

Applications

1-chloro-1,2,2,2-tetrafluororethane is commonly used as a refrigerant gas. It is a hydrochlorofluorocarbon (HCFC) and is given the ASHRAE number R-124. It is used in both a pure form, as a retrofit replacement for CFC-114 in certain applications, and as a component in a number of HCFC refrigerant blends.



Note:

1-chloro-1,2,2,2-tetrafluororethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		136.48		
Boiling point	at 1.013 bar [°C]	-10.8	at 14.5 psi [°F]	12.6
Density	at 1.013 bar, 15 °C [kg/m^3]	5.877	at 1 atm., 60 °F [lb/ft^3]	0.3669
Vapour pressure	at 0 °C [bar]	1.6	at 32 °F [psi]	23.7
	at 20 °C [bar]	3.3	at 70 °F [psi]	47.9
Flammability range in air [% volume]		Not combustible		

Chlorodifluoroethane $C_2H_3ClF_2$

1-Chloro-1,1-difluoroethane, HCFC-142b, R-142b

CAS: 75-68-3
EC: 200-891-8
UN: 2517
R-142b

Purity grade	Typical purity	Typical impurities [ppm]
		Air
Chlorodifluoroethane 1.8	≥98 %	≤20,000

Typical filling pressure: 15 °C: 3 bar(a)/70 °F: 28.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless, liquefied gas. Dry gas is not corrosive. Decomposes at high temperatures to toxic substances. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas; **H420 –** Harms public health and the environment by destroying ozone in the upper atmosphere.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM CONSTR FOOD PETRO

Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for chlorodifluoroethane uses dichloroethylene which is reacted with HF in the presence of a catalyst.

Applications

Chlorodifluoroethane is used as a refrigerant gas. It is a hydrochlorofluorocarbon (HCFC) and is given the ASHRAE number R-142b. It is commonly used in refrigerant blends such as HCFC-409A and HCFC-409B.

Other applications include chlorodifluoroethane as a foam blowing agent for polyurethane foams and extruded polystyrene foams.

Note:

Chlorodifluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		100.5		
Boiling point	at 1.013 bar [°C]	-9.2	at 14.5 psi [°F]	15.4
Density	at 1.013 bar, 15 °C [kg/m³]	4.357	at 1 atm., 70 °F [lb/ft³]	0.272
Vapour pressure	at 0 °C [bar]	1.49	at 32 °F [psi]	21.6
	at 20 °C [bar]	3.39	at 70 °F [psi]	49.2
Flammability range in air [% volume]		6.3 – 17.9		

Chlorodifluoromethane $CHClF_2$

HCFC-22, R-22

CAS: 75-45-6
EC: 200-871-9
UN: 1018
R-22

Purity grade	Typical purity	Typical impurities [ppm]
		Air
Chlorodifluoromethane 3.0	≥99.9 %	≤1,000

Typical filling pressure: 15 °C: 8 bar(a)/70 °F: 101.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics
Colourless, odourless, liquefied gas. Decomposes at high temperatures to toxic substances. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

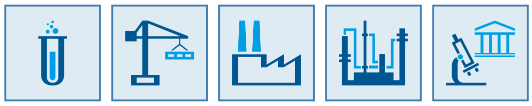
Proposed by the Industry
Signal word: **WARNING**

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H420 –** Harms public health and the environment by destroying ozone in the upper atmosphere; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2



Source

Chlorodifluoromethane is prepared by treating chloroform with anhydrous hydrogen fluoride in the presence of a small amount of antimony chloride at elevated temperatures and pressures.

Applications

Chlorodifluoromethane (R-22) is a versatile refrigerant used extensively for a wide range of temperatures in many types of refrigeration and stationary air conditioning systems in industrial, commercial and domestic applications.

Chlorodifluoromethane is used as an intermediate in the production of Teflon®.

As an aerosol propellant, chlorodifluoromethane is only used in special cases, such as for very low temperature spraying.

Chlorodifluoromethane may also be used in the production of fluorinated polymers and for leak detection.

In some geographies, the sale and/or use of R22 may be restricted or even prohibited (Montreal Protocol). Phase-out processes may exceptionally allow the use of recycled product.

Note:

Chlorodifluoromethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		86.468		
Boiling point	at 1.013 bar [°C]	−40.83	at 14.5 psi [°F]	−41.47
Density	at 1.013 bar, 15 °C [kg/m³]	3.719	at 1 atm., 70 °F [lb/ft³]	0.227
Vapour pressure	at 0 °C [bar]	4.94	at 32 °F [psi]	71.69
	at 20 °C [bar]	8.97	at 70 °F [psi]	134.12
Flammability range in air [% volume]		Non combustible		

Chloroethene C_2H_3Cl

Chloroethylene, Vinyl chloride

CAS: 75-01-4
EC: 200-831-0
UN: 1086
R-1140

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Chloroethene 3.7	≥99.97 %	contact local team

Typical filling pressure: 15 °C: 2.3 bar(a)/70 °F: 36.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable, colourless, liquefied gas with pleasurable sweet odour in high concentrations. Polymerizes in the presence of air or sunlight. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: **DANGER**

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H231** – May react explosively even in absence of air at elevated pressure and/or temperature; **H350** – May cause cancer.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM CONSTR ENERGY MANUF R&D

Source

Chloroethene is industrially produced using many different reaction paths as there are

a. catalytic chlorination reacting ethene and chlorine
b. high-temperature chlorination of ethane with chlorine with a chlorine/ oxygen blend and last but not least with a hydrogen chloride/oxygen mixture
c. catalytical chlorination of acetylene in with hydrogen chloride
d. catalytical oxychlorination reacting acetylene , hydrogen chloride and oxgen
e. thermal decompositionof 1,2-dichloroethane industrially produced in a direct reaction of carbon, boron oxide and chlorine at 500°C.

Applications

Chloroethene is largely used as an intermediate in organic synthesis.

Chloroethene is used as a raw material in the polymerisation of ethenyl resins (polyvinyl chloride, PVC). This polymerisation occurs in various ways, depending on the type of product which is desired:

→ mass or block polymerisation; the final product is very pure and serves primarily as a rigid, high-quality material.
→ solution polymerisation; the final product appears in a stable solution with a low index of viscosity. Hence it can be employed in the cement, lacquer and paint industries.
→ precipitation polymerisation; a pure, homogeneous product is obtained with a low index of viscosity, hence its suitability for use in the paint and glue industry.
→ emulsion polymerisation; the product obtained may be polluted by water-soluble impurities. This process is satisfactory for plastisols.
→ suspension polymerisation; a pure product is obtained, which may be used for perfectly transparent articles.

Chloroethene is used as a component in mixtures for workspace and industrial emission control.

Chloroethene has been used as a refrigerant and has the ASHRAE number R-1140.

Physical data

Molecular weight		62.499		
Boiling point	at 1.013 bar [°C]	−13.37	at 14.5 psi [°F]	7.95
Density	at 1.013 bar, 15 °C [kg/m^3]	2.703	at 1 atm., 70 °F [lb/ft^3]	0.165
Vapour pressure	at 0 °C [bar]	1.7	at 32 °F [psi]	25.32
	at 20 °C [bar]	3.42	at 70 °F [psi]	51.26
Flammability range in air [% volume]		3.8 – 31.0		

Chloropentafluoroethane C_2ClF_5

CFC-115, R-115

CAS: 76-15-3
EC: 200-938-2
UN: 1020
R-115

Purity grade	Typical purity	Typical impurities [ppm]
		Air
HiQ® Chloropentafluoroethane 3.0	≥99.9 %	≤1,000

Typical filling pressure: 15 °C: 7 bar(a)/70 °F: 104.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, odourless, liquefied gas. Can decompose to toxic substances at high temperature. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: **WARNING**

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H420** – Harms public health and the environment by destroying ozone in the upper atmosphere; **EIGA-As** – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CHEM CONSTR MANUF R&D SEMI

Source

Commercial production of chlorofluoroalkanes employs halogen exchange, with hydrogen fluoride in the liquid phase in the presence of a catalyst. Different starting materials are used depending on the desired product. Some commonly used starting materials are carbon tetrachloride, chloroform, tetrachloroethylene and trichloroethylene. The main catalysts used are antimony halides with low volatility.

More recently developed exchange processes are carried out continuously in the gas phase at 100–400°C, using catalysts based on chromium, aluminium or iron.

The composition of the product can be controlled within wide limits by varying temperature, pressure, residence time, catalysts and the portions of the reactants.

Unreacted material is separated from the crude mixture by fractional distillation and recycled. Further treatment of the products includes washing, drying and distillation.

In the Montedison chlorofluorination process, reaction of C_1 and C_2 hydrocarbons with chlorine and hydrogen fluoride takes place in a single step in a fluidised bed reactor. The catalyst used is based on aluminium chloride.

Commercial production of chlorofluoroalkanes is also possible by the electrochemical fluorination process developed by Phillips Petroleum.

Applications

Chloropentafluoroethane is used as:
- → a refrigerant
- → a propellant in aerosols
- → a chemical intermediate.

Note:

Chloropentafluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		154.47		
Boiling point	at 1.013 bar [°C]	−39.11	at 14.5 psi [°F]	−38.38
Density	at 1.013 bar, 15 °C [kg/m^3]	6.687	at 1 atm., 70 °F [lb/ft^3]	0.408
Vapour pressure	at 0 °C [bar]	4.4	at 32 °F [psi]	64.5
	at 20 °C [bar]	8.0	at 70 °F [psi]	119.5
Flammability range in air [% volume]		Non combustible		

Cyanic chloride CNCl

Cyanogen chloride

CAS: 506-77-4
EC: 208-052-8
UN: 1589

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Cyanic chloride 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 1.1 bar(a)/70 °F: 5.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Liquefied colourless gas with a pungent odour. Forms white fumes in humid air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

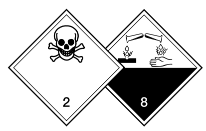
Proposed by the Industry

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM R&D

Source

Cyanic chloride is prepared by oxidation of sodium cyanide with chlorine.

Cyanic chloride can also be prepared by chlorinating an aqueous suspension of potassium zinc cyanide.

Applications

Cyanic chloride is a precursor to sulfonyl cyanides and chlorosulfonyl isocyanate.

Cyanic chloride is a useful reagent in organic synthesis.

Physical data

Molecular weight		61.47		
Boiling point	at 1.013 bar [°C]	12.85	at 14.5 psi [°F]	55.20
Density	at 1.013 bar, 15 °C [kg/m³]	2.678	at 1 atm., 70 °F [lb/ft³]	0.163
Vapour pressure	at 0 °C [bar]	0.59	at 32 °F [psi]	8.61
	at 20 °C [bar]	1.35	at 70 °F [psi]	20.41
Flammability range in air [% volume]		Non combustible		

Cyclopentane C_5H_{12}

Pentamethylene

CAS: 287-92-3
EC: 206-016-6
UN: 1146

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
Cyclopentane	≥95 %	≤100 ppm(w)

Typical filling pressure: 15 °C: 0.28 bar(a)/70 °F: 5.02 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics
Flammable. Colourless liquid with a petrol-like odour. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: **DANGER**

H-statements:
H225 - Highly flammable liquid and vapour; **H304** - May be fatal if swallowed and enters airways; **H336** - May cause drowsiness or dizziness; **H412** - Harmful to aquatic life with long lasting effects; **EUH066** - Repeated exposure may cause skin dryness or cracking.

Transport of dangerous goods

ADR Class 3, F1

DOT Class 3

CHEM CONSTR FOOD MANUF PETRO

Source

Cyclopentane can be formed by catalytic reforming. This specific process reforms iso-Pentane (2-methylbutane) using a platinum catalyst.

Applications

Pentanes are some of the primary blowing agents used in the production of polystyrene foam and other foams. Often a mixture of n-Pentane, i-Pentane and increasingly cyclopentane is used. They have replaced fluorocarbon gases due to their zero ozone depletion and low global warming potential.

Physical data

Molecular weight		72.15		
Boiling point	at 1.013 bar [°C]	49.3	at 14.5 psi [°F]	120.7
Density	at 1.013 bar, 20 °C [kg/m^3]	0.74	at 1 atm., 70 °F [lb/ft^3]	0.0462
Vapour pressure	at 0 °C [bar]	0.14	at 32 °F [psi]	2.0
	at 20 °C [bar]	0.35	at 70 °F [psi]	5.02
Flammability range in air [% volume]		1.1 – 8.7		

Cyclopropane C_3H_6

CAS: 75-19-4
EC: 200-847-8
UN: 1027

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
HiQ® Cyclopropane 2.0	≥99 %	≤10,000

Typical filling pressure: 15 °C: 2.9 bar(a)/70 °F: 27.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable, liquefied, colourless gas with a characteristic odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: **DANGER**

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM MEDICAL PETRO R&D

Source

Cyclopropanes can be prepared in the laboratory by organic synthesis in various ways. Many methods are simply called cyclopropanation.

Most common generation route is the catalytic reaction of 1,3-dibromopropane, e.g. in the presence of sodium or zinc.

Applications

Cyclopropane is used as a component in calibration gases for the gas, oil and chemical industries.

Cyclopropane is still used as an intermediate in organic synthesis.

Cyclopropane is used as a plasma etching agent.

Cyclopropane was used as an anaesthetic when inhaled. In modern anaesthetic practice, it has been superseded by other agents, due to its high cost and extreme reactivity under normal conditions. If used today, it may be classified as a medical device in some geographies and managed according to relevant regulations.

Physical data

Molecular weight		42.081		
Boiling point	at 1.013 bar [°C]	−32.78	at 14.5 psi [°F]	−26.98
Density	at 1.013 bar, 15 °C [kg/m³]	1.812	at 1 atm., 70 °F [lb/ft³]	0.111
Vapour pressure	at 0 °C [bar]	3.45	at 32 °F [psi]	50.06
	at 20 °C [bar]	6.29	at 70 °F [psi]	94.11
Flammability range in air [% volume]		2.4 – 10.4		

Deuterium D_2

CAS: 7782-39-0
EC: 231-952-7
UN: 1957

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Deuterium	≥99.9 % (D_2/(D_2+H_2)>99.8 %)	

Typical filling pressure: 15 °C: 200 bar(a)/70 °F: 2,000 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Colourless and odourless. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: DANGER

H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 1F

DOT Class 2.1

CHEM ENERGY MANUF MEDICAL R&D SEMI

Source

Deuterium is prepared by electrolysis of heavy water (D_2O).

Applications

Deuterium is used in nuclear research as a projectile in deuterium accelerators, and as a source of neutrons when it is irradiated with [illegible] energy rays.

Deuterium is used in physics experiments, such as thermal fusion studies.

It is also used in chemical research, where it is used to label hydrogen-containing molecules and hence to study reactions involving these.

Deuterium is used in electronics as a replacement for hydrogen in the annealing or sintering of silicon-based semiconductors, flat panel displays and solar panels.

Deuterium is used as a trace marker of organic molecules used in CAT (Computed Axial Tomography) scanning studies.

Deuterium is used in HF/DF chemical lasers (see page 127).

Physical data

Molecular weight		4.032		
Boiling point	at 1.013 bar [°C]	−249.5	at 14.5 psi [°F]	−417.07
Density	at 1.013 bar, 15 °C [kg/m³]	0.171	at 1 atm., 70 °F [lb/ft³]	0.010
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		6.7 – 79.6		

Diborane B_2H_6

CAS: 19287-45-7
EC: 242-940-6
UN: 1911

Purity grade	Typical purity	Typical impurities [ppm]				
		N_2	B_nH_{2n+2}(n>2)	CH_4	H_2	CO_2
HiQ® Diborane 4.0	≥99.99 %	≤10	≤3	≤5	≤500	≤5

Typical filling pressure: 15 °C: 26.8 bar(a)/70 °F: 332.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Colourless gas with a sickly-sweet odour. Flammable, unstable. Gas density is slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: **DANGER**

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H330** – Fatal if inhaled.

Transport of dangerous goods

ADR Class 2, 2TF

DOT Class 2.3

CHEM MANUF METAL PETRO R&D SEMI

Source

Diborane is manufactured by addition of boron trifluoride to a solution of sodium borohydride in diethylene glycol dimethyl ether.

Another industrial reaction path uses the hydrogenation of diboron trioxide in the presence of catalytic aluminium in a high-pressure hydrogen atmosphere.

Applications

Diborane is a catalyst for ethylenic, styrene, acrylic and vinyl polymerisation.

Diborane serves as a strong but selective reducing agent in organic chemistry. Typical products synthesised are nitriles, aldehydes, ketones, esters, epoxides and amides.

Diborane is used as a rubber vulcaniser. Diborane is used as a reducing agent.
Diborane is used as a flame speed accelerator.
Diborane is an intermediate for preparation of boron hydrides of higher molecular weight.

Diborane may be used in rocket propellants as a reducing agent.

Diborane is used for conversion of olefins to trialkyl boranes and primary alcohols.

The addition of diborane to olefins (hydroboration) has great significance in preparative chemistry. In the presence of an ether, diborane forms an alkyl borane, in an anti-Markownikoff mode.

Further areas of application for diborane are the doping of semiconductor silicon and germanium.

Diborane is used in the process of creating hardened metal surfaces for better wear resistance.

Physical data

Molecular weight		27.67		
Boiling point	at 1.013 bar [°C]	−92.5	at 14.5 psi [°F]	−134.48
Density	at 1.013 bar, 15 °C [kg/m^3]	1.181	at 1 atm., 70 °F [lb/ft^3]	0.072
Vapour pressure	at 0 °C [bar]	26.8	at 32 °F [psi]	388
	at 20 °C [bar]	43.5	at 70 °F [psi]	588
Flammability range in air [% volume]		0.9 – 98.0		

1,1-Dichloro-1-fluoroethane $C_2H_3Cl_2F$

HCFC-141b, R-141b

CAS: 1717-00-6
EC: 404-080-1
UN: not applicable
R-141b

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
1,1-Dichloro-1-fluoroethane	≥99.9 %	≤50 ppm(w)

Typical filling pressure: 21.1 °C: 2.3 bar(a)/70 °F: 33.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Colourless liquid with a slight ethereal smell. Flammable only under specific conditions. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: WARNING

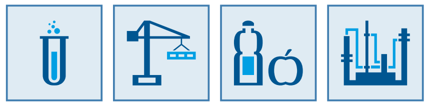
H-statements:

H412 - Harmful to aquatic life with long lasting effects; H420 - Harms public health and the environment by destroying ozone in the upper atmosphere.

Transport of dangerous goods

ADR not applicable

DOT not applicable



CHEM CONSTR FOOD PETRO

Source

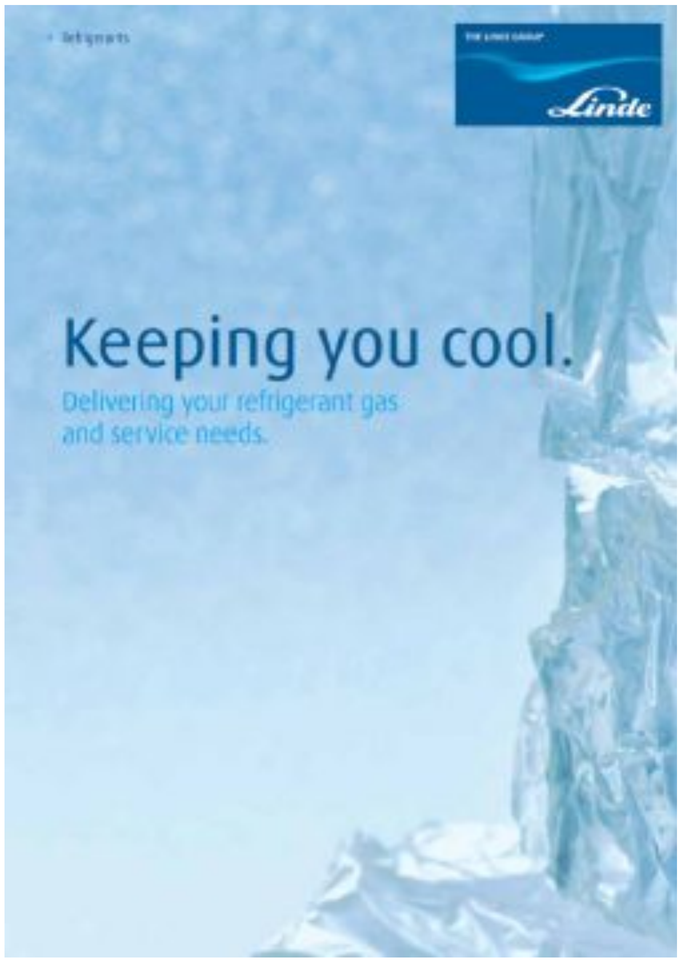
Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for 1,1-dichloro-1-fluoroethane uses dichloroethylene which is reacted with HF in the presence of a catalyst.

Applications

1,1-dichloro-1-fluoroethane (HCFC-141b) is widely used as a foam blowing agent. It was also used historically as a solvent. It is also sometimes used as a refrigerant gas, and is given the ASHRAE number R-141b.

Note:

1,1-dichloro-1-fluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.



Physical data

Molecular weight		116.95		
Boiling point	at 1.013 bar [°C]	32	at 14.5 psi [°F]	89.6
Density	at 1.013 bar, 10 °C [kg/m^3]	1.25	at 1 atm., 50 °F [lb/ft^3]	0.0780
Vapour pressure	at 0 °C [bar]	0.28	at 32 °F [psi]	4.1
	at 20 °C [bar]	0.65	at 70 °F [psi]	33.2
Flammability range in air [% volume]		5.6 – 17.7		

2,2-Dichloro-1,1,1-trifluoroethane $C_2HCl_2F_3$

HCFC-123, R-123

CAS: 306-83-2
EC: 206-190-3
UN: not applicable
R-123

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
2,2-Dichloro-1,1,1-trifluoroethane	≥99.8 %	≤10 ppm(w)

Typical filling pressure: 15 °C: 0.62 bar(a)/70 °F: 13.81 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Colourless liquid with a slight ether-like smell. Stable at normal temperatures and storage conditions. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

H371 - May cause damage to CNS, liver; **H373** - May cause damage to liver through prolonged or repeated exposure; **H420** - Harms public health and the environment by destroying ozone in the upper atmosphere.

Transport of dangerous goods

ADR not applicable

DOT not applicable

CHEM CONSTR FOOD PETRO

Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. Many synthesis routes for 2,2-dichloro-1,1,1-trifluoroethane use trichloroethylene and/or tetrachloroethylene (also known as perchloroethylene, PCE), which is reacted with HF, often in the presence of a catalyst.

Applications

2,2-dichloro-1,1,1-trifluoroethane is commonly used as a refrigerant gas. It is a hydrochlorofluorocarbon (HCFC) and is given the ASHRAE number R-123. It is used as a retrofit alternative to CFC-11 and CFC-113 in low pressure centrifugal chillers.

Note:

2,2-dichloro-1,1,1-trifluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		152.93		
Boiling point	at 1.013 bar [°C]	27.8	at 14.5 psi [°F]	82.0
Density	at 1.013 bar, 20 °C [kg/m^3]	1.48	at 1 atm., 70 °F [lb/ft^3]	0.0924
Vapour pressure	at 0 °C [bar]	0.32	at 32 °F [psi]	4.7
	at 20 °C [bar]	0.50	at 70 °F [psi]	13.81
Flammability range in air [% volume]		Not combustible		

Dichlorodifluoromethane CCl_2F_2

CFC-12, R-12

CAS: 75-71-8
EC: 200-893-9
UN: 1028
R-12

Purity grade	Typical purity	Typical impurities [ppm]
Dichlorodifluoromethane 2.8	≥99.8 %	contact local team

Typical filling pressure: 15 °C: 4.9 bar(a)/70 °F: 69.5 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas. Ether-like odour at high concentrations. Decomposes at high temperature to toxic substances. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H412 – Harmful to aquatic life with long lasting effects; H420 – Harms public health and the environment by destroying ozone in the upper atmosphere; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CONSTR ENERGY FOOD MANUF R&D

Source

Commercial production of chlorofluoroalkanes employs halogen exchange, with hydrogen fluoride in the liquid phase in the presence of a catalyst. Different starting materials are used depending on the desired product. Some commonly used starting materials are carbon tetrachloride, chloroform, tetrachloroethylene and trichloroethylene. The main catalysts used are antimony halides with low volatility.

More recently developed exchange processes are carried out continuously in the gas phase at 100–400°C, using catalysts based on chromium, aluminium or iron.

The composition of the product can be controlled within wide limits by varying temperature, pressure, residence time, catalysts and the portions of the reactants.

Unreacted material is separated from the crude mixture by fractional distillation and recycled. Further treatment of the products includes washing, drying and distillation.

In the Montedison chlorofluorination process, reaction of C_1 and C_2 hydrocarbons with chlorine and hydrogen fluoride takes place in a single step in a fluidised bed reactor. The catalyst used is based on aluminium chloride.

Commercial production of chlorofluoroalkanes is also possible by the electrochemical fluorination process developed by Phillips Petroleum.

Applications

Dichlorodifluoromethane (R-12) has been phased out in many geographies under the Montreal Protocol.

It can be used in the following applications:
- → low-temperature air conditioning
- → storage of food products
- → air conditioning of offices, workshops, stores
- → domestic, commercial and industrial refrigeration.

It may also be used as:
- → an aerosol propellant
- → a swelling agent (rigid foam production)
- → a leak detector
- → a gas phase dielectric.

Note:

Dichlorodifluoromethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		120.91		
Boiling point	at 1.013 bar [°C]	–29.79	at 14.5 psi [°F]	–21.60
Density	at 1.013 bar, 15 °C [kg/m³]	5.231	at 1 atm., 70 °F [lb/ft³]	0.319
Vapour pressure	at 0 °C [bar]	3.08	at 32 °F [psi]	44.67
	at 20 °C [bar]	5.63	at 70 °F [psi]	84.23
Flammability range in air [% volume]		Non combustible		

Dichlorofluoromethane $CHCl_2F$

HCFC-21, R-21

CAS: 75-43-4
EC: 200-869-8
UN: 1029
R-21

Purity grade	Typical purity	Typical impurities [ppm]
		Air
HiQ® Dichlorofluoromethane 3.0	≥99.9 %	≤1,000

Typical filling pressure: 15 °C: 1.5 bar(a)/70 °F: 8.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics
Colourless, liquefied gas. Can decompose to toxic substances at high temperatures. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: **WARNING**

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H420** – Harms public health and the environment by destroying ozone in the upper atmosphere; **EIGA-As** – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CHEM MANUF R&D

Source

Commercial production of chlorofluoroalkanes employs halogen exchange, with hydrogen fluoride in the liquid phase in the presence of a catalyst. Different starting materials are used depending on the desired product. Some commonly used starting materials are carbon tetrachloride, chloroform, tetrachloroethylene and trichloroethylene. The main catalysts used are antimony halides with low volatility.

More recently developed exchange processes are carried out continuously in the gas phase at 100–400°C, using catalysts based on chromium, aluminium or iron.

The composition of the product can be controlled within wide limits by varying temperature, pressure, residence time, catalysts and the portions of the reactants.

Unreacted material is separated from the crude mixture by fractional distillation and recycled. Further treatment of the products includes washing, drying and distillation.

In the Montedison chlorofluorination process, reaction of C_1 and C_2 hydrocarbons with chlorine and hydrogen fluoride takes place in a single step in a fluidised bed reactor. The catalyst used is based on aluminium chloride.

Commercial production of chlorofluoroalkanes is also possible by the electrochemical fluorination process developed by Phillips Petroleum.

Applications

Dichlorofluoromethane (R-21) has been set to be phased out in many geographies under the Montreal Protocol.

Dichlorofluoromethane (R-21) is used as a refrigerant for the air conditioning of very hot atmospheres.

It has been mainly used as:
- → an aerosol propellant
- → a solvent
- → a chemical intermediate.

Note:

Dichlorofluoromethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		102.92		
Boiling point	at 1.013 bar [°C]	8.9	at 14.5 psi [°F]	48.04
Density	at 1.013 bar, 15 °C [kg/m^3]	4.493	at 1 atm., 70 °F [lb/ft^3]	0.274
Vapour pressure	at 0 °C [bar]	0.71	at 32 °F [psi]	10.26
	at 20 °C [bar]	1.53	at 70 °F [psi]	23.0
Flammability range in air [% volume]		Non combustible		

Dichlorosilane SiH_2Cl_2

CAS: 4109-96-0
EC: 223-888-3
UN: 2189

Purity grade	Typical purity	Typical impurities [ppm] C	Fe	B	P	As	Other chlorosilane
HiQ® Dichlorosilane 2.0	≥99 % (by weight) – Resistivity >50 Ω/cm	≤5 ppm(w)	≤50 ppb(w)	≤0.5 ppb(w)	≤0.5 ppb(w)	≤0.5 ppb(w)	≤1 %
HiQ® Dichlorosilane 3.0	≥99.9 % (by weight) – Resistivity >150 Ω/cm	≤1 ppm(w)	≤25 ppb(w)	≤0.1 ppb(w)	≤0.2 ppb(w)	≤0.3 ppb(w)	≤0.1 %

Typical filling pressure: 15 °C: 1.3 bar(a)/70 °F: 8.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

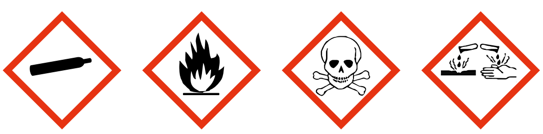
Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Liquefied gas with pungent odour. Highly corrosive in humid conditions. Gas density is heavier than air.

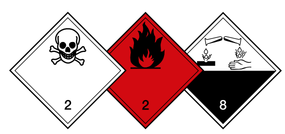
Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)
Proposed by the Industry
Signal word: DANGER

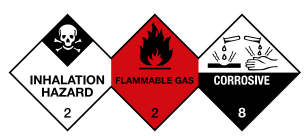


H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H330** – Fatal if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TFC



DOT Class 2.3

CHEM R&D SEMI

Source

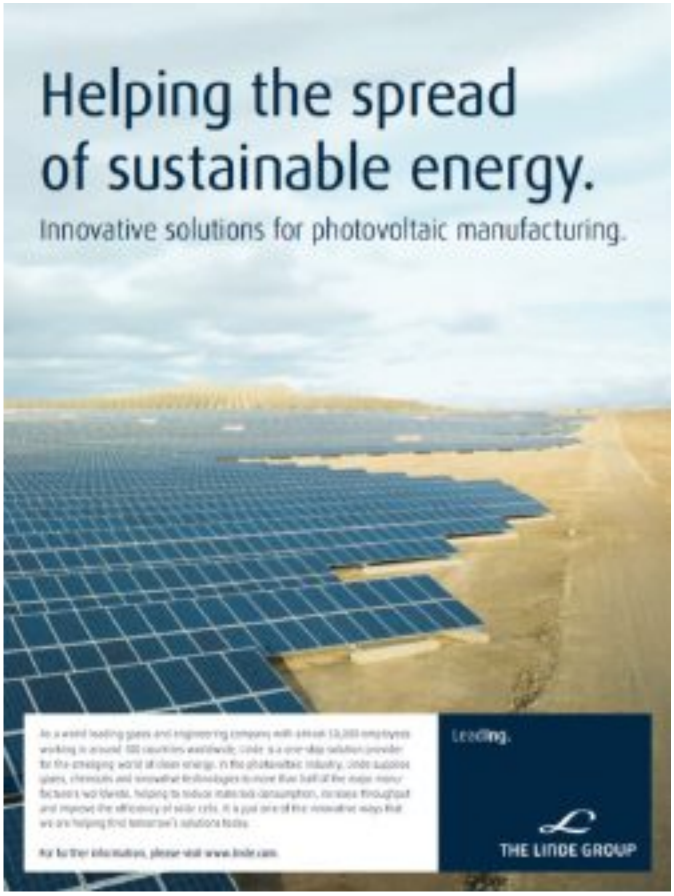
Dichlorosilane is produced (along with other chlorosilanes, such as trichlorosilane) by the reaction of a mixture of hydrogen and hydrogen chloride with silicon at high temperatures.

It is also prepared (5% yield) by disproportionation of trichlorosilane by heating to 300–400°C in the presence of catalysts, e.g. aluminium chloride, ferric chloride and boron trifluoride.

Applications

Used in the manufacturing of organosilicon compounds (silane coupling agents).

Dichlorosilane is used as a silicon source for low-pressure chemical vapour deposition of polysilicon, silicon dioxide, silicon nitride and epitaxial silicon.



Physical data

Molecular weight		101.01		
Boiling point	at 1.013 bar [°C]	8.3	at 14.5 psi [°F]	46.96
Density	at 1.013 bar, 15 °C [kg/m^3]	4.426	at 1 atm., 70 °F [lb/ft^3]	0.217
Vapour pressure	at 0 °C [bar]	0.73	at 32 °F [psi]	10.59
	at 20 °C [bar]	1.52	at 70 °F [psi]	22.90
Flammability range in air [% volume]		2.5 – 80.0		

1,2-Dichlorotetrafluoroethane $C_2Cl_2F_4$

CFC-114, R-114

CAS: 76-14-2
EC: 200-869-8
UN: 1958
R-114

Purity grade	Typical purity	Typical impurities [ppm]
1,2-Dichlorotetrafluoroethane	on request	contact local team

Typical filling pressure: 15 °C: 1.5 bar(a)/70 °F: 12.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas. Decomposes at high temperatures to toxic substances. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

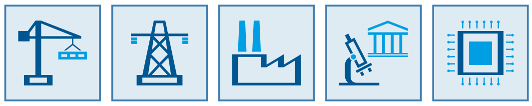
H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H420** – Harms public health and the environment by destroying ozone in the upper atmosphere; **EIGA-As** – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2



Source

1,2-Dichlorotetrafluoroethane is obtained by treating hexachloroethane with anhydrous hydrogen fluoride under high pressure in the presence of small amounts of antimony chloride.

Applications

1,2-Dichlorotetrafluoroethane (R-114) is used in small refrigeration systems with rotary compressors, and in large industrial water cooling and air conditioning systems using multi-stage centrifugal compressors.

1,2-Dichlorotetrafluoroethane finds widespread use, either alone or in mixtures with dichlorodifluoromethane, as an aerosol propellant, particularly for cosmetics as it is practically odourless and causes no undesirable effect when applied to the skin.

1,2-Dichlorotetrafluoroethane is used for foam blowing.

1,2-Dichlorotetrafluoroethane is used for heat pumps.

1,2-Dichlorotetrafluoroethane is also used for cleaning of electronic parts.

Note:

1,2-Dichlorotetrafluoroethane is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		170.92		
Boiling point	at 1.013 bar [°C]	3.77	at 14.5 psi [°F]	38.81
Density	at 1.013 bar, 15 °C [kg/m^3]	7.532	at 1 atm., 70 °F [lb/ft^3]	0.459
Vapour pressure	at 0 °C [bar]	0.88	at 32 °F [psi]	12.81
	at 20 °C [bar]	1.84	at 70 °F [psi]	27.43
Flammability range in air [% volume]		Non combustible		

1,1-Difluoroethane $C_2H_4F_2$

Difluoroethane, Ethylidene difluoride, HFC-152a, R-152a

CAS: 75-37-6
EC: 200-866-1
UN: 1030
R-152a

Purity grade	Typical purity	Typical impurities [ppm]
1,1-Difluoroethane 3.0	≥99.9 %	contact local team

Typical filling pressure: 15 °C: 5.2 bar(a) /70 °F: 62.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless, liquefied gas. Dry gas is not corrosive. Decomposes at high temperatures to toxic substances. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM CONSTR MANUF PETRO R&D

Source
1,1-Difluoroethane is manufactured by catalytic addition of hydrogen fluoride to acetylene.

Applications
1,1-Difluoroethane (R-152a) is used:
→ in the formulation of aerosol dispersants with stringent environmental VOC demands
→ as a low-temperature solvent
→ in refrigeration systems where its flammability is not a major factor and as a component in some hydrochlorofluorocarbon (HCFC) refrigerant blends (HCFCs replace chlorofluorocarbons (CFCs)
→ as an organic synthesis intermediate.

Note:
1,1-Difluoroethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		66.051		
Boiling point	at 1.013 bar [°C]	−25.8	at 14.5 psi [°F]	14.42
Density	at 1.013 bar, 15 °C [kg/m³]	2.857	at 1 atm., 70 °F [lb/ft³]	0.174
Vapour pressure	at 0 °C [bar]	2.69	at 32 °F [psi]	38.97
	at 20 °C [bar]	5.17	at 70 °F [psi]	77.60
Flammability range in air [% volume]		4.0 – 20.2		

1,1-Difluoroethylene $C_2H_2F_2$

1,1-Difluoroethene, HFC-1132a, R-1132a

CAS: 75-38-7
EC: 200-867-7
UN: 1959
R-1132a

Purity grade	Typical purity	Typical impurities [ppm]
1,1-Difluoroethylene 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 32.3 bar(a)/70 °F: 521.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless, liquefied gas. Dry gas is not corrosive. Can decompose to toxic substances at high temperatures. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO R&D

Source

1,1-Difluoroethylene can be obtained by dehydrochlorination of 1-chloro-1,1-difluoroethane (R-142b).

1,1-Difluoroethylene is produced by passing a mixture of hydrogen and 1,2-dichloro-1,1-difluoroethane over nickel wire at an elevated temperature.

Two other reaction paths use dechlorination of 1,2-dichloro-1,1-difluoroethane (R152a) or the dehydrofluorination of 1,1,1-trifluoroethane (R143a).

Applications

1,1-Difluoroethylene is used for the preparation of polymers like polyvinyledene polymers and for copolymers together with chlorotrifluoroethylene or hexafluoropropylene (TFB).

1,1-Difluoroethylene is used as an intermediate in organic synthesis.

Physical data

Molecular weight		64.035		
Boiling point	at 1.013 bar [°C]	−85.65	at 14.5 psi [°F]	14.42
Density	at 1.013 bar, 15 °C [kg/m^3]	2.732	at 1 atm., 70 °F [lb/ft^3]	0.174
Vapour pressure	at 0 °C [bar]	22.6	at 32 °F [psi]	327.7
	at 20 °C [bar]	36.1	at 70 °F [psi]	536.5
Flammability range in air [% volume]		4.7 – 25.1		

Difluoromethane CH_2F_2

Methylene fluoride, HFC-32, R-32

CAS: 75-10-5
EC: 200-839-4
UN: 3252
R-32

Purity grade	Typical purity	Typical impurities [ppm]
Difluoromethane 3.0	≥99.9 %	contact local team

Typical filling pressure: 15 °C: 12.8 bar(a)/70 °F: 185 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: **DANGER**

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

MANUF R&D SEMI

Source
Difluoromethane is produced by reacting methyl chloride with hydrogen fluoride in the presence of a catalyst.

Applications
Difluoromethane is used in plasma etching of silicon layers.

Difluoromethane (R-32) has been mainly used as a refrigerant.

Difluoromethane may also be used in cooling aerosols.

Note:
Difluoromethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		52.02		
Boiling point	at 1.013 bar [°C]	−51.65	at 14.5 psi [°F]	−60.97
Density	at 1.013 bar, 15 °C [kg/m^3]	2.180	at 1 atm., 70 °F [lb/ft^3]	0.136
Vapour pressure	at 0 °C [bar]	8.1	at 32 °F [psi]	117.5
	at 20 °C [bar]	14.7	at 70 °F [psi]	219.8
Flammability range in air [% volume]		14.0 – 33.0		

Dimethyl ether C_2H_6O

Methoxymethane, Dimethyl oxide

CAS: 115-10-6
EC: 204-065-8
UN: 1033

Purity grade	Typical purity	Typical impurities [ppm]
Dimethyl ether 3.0	≥99.9 %	contact local team

Typical filling pressure: 15 °C: 4.4 bar(a)/70 °F: 62.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Liquefied colourless gas with ether like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

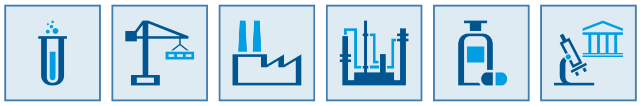
H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1



CHEM CONSTR MANUF PETRO PHARMA R&D

Source

Dimethyl ether is prepared from synthesis gas either in a one-step or a two-step process. The intermediate methanol may also be gained from biomass. This calls either for a single catalyst (1-step) or a dual catalyst (2-step) reaction system. The latter reaction does not require methanol separation and purification, but does entail a higher start-up cost.

Applications

Dimethyl ether finds commercial use as a refrigerant.

Dimethyl ether is used as a solvent, as an extraction agent and as a propellant in aerosols, especially those for personal care products such as hairsprays.

Dimethyl ether is also used as a fuel for forklifts and for welding, cutting and brazing.

Dimethyl ether readily forms complexes with inorganic compounds, e.g. boron trifluoride. It is an excellent methylating agent, e.g. for conversion of aniline into dimethylaniline in the dye industry.

Dimethyl ether is used in the chemical industry in the manufacture of synthetic rubber.

Dimethyl ether is industrially important as the starting material in the production of dimethyl sulfate. (Dimethyl sulfate is employed as a methylating agent.)

Dimethyl ether reacted with carbon monoxide could be used in the large-scale production of acetic acid in place of methanol.

Future industrial uses of dimethyl ether include the production of olefins in the presence of zeolitic catalysts. The production of saturated hydrocarbons can be carried out by an analogous process.

Dimethyl ether is also used in the methanol to gasoline conversion process, and is under consideration for use in European biofuel mixtures.

Physical data

Molecular weight		46.069		
Boiling point	at 1.013 bar [°C]	−24.84	at 14.5 psi [°F]	−12.69
Density	at 1.013 bar, 15 °C [kg/m^3]	1.988	at 1 atm., 70 °F [lb/ft^3]	0.121
Vapour pressure	at 0 °C [bar]	2.65	at 32 °F [psi]	38.42
	at 20 °C [bar]	5.09	at 70 °F [psi]	76.35
Flammability range in air [% volume]		2.7 – 32.0		

Dimethylamine $(CH_3)_2NH$

CAS: 124-40-3
EC: 204-697-4
UN: 1032

Purity grade	Typical purity	Typical impurities [ppm]
		Other amines
Dimethylamine 2.0	≥99 %	≤1 %

Typical filling pressure: 15 °C: 1.4 bar(a)/70 °F: 11 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Liquefied colourless gas with strong ammonia/fish-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H332** – Harmful if inhaled; **H335** – May cause respiratory irritation; **H315** – Causes skin irritation; **H318** – Causes serious eye damage.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM FOOD MANUF METAL PETRO PHARMA R&D

Source

Dimethylamine is prepared commercially either by a reaction between methanol and ammonia, or alternatively by a reaction of a carbonyl compound and ammonia.

Monomethylamine and trimethylamine are formed in the same reaction and the three products are then separated by distillation.

Applications

Dimethylamine has been used as a de-hairing agent in tanning.

Dimethylamine:

- → is used as an acid gas absorbent.
- → is used as a flotation agent.
- → is used as a gasoline stabiliser.
- → is used as a raw material in pharmaceuticals.
- → is used in rubber accelerators.
- → is used in soaps and cleaning compounds.
- → is used in the treatment of cellulose acetate rayon.
- → is used in organic synthesis.
- → is used as a raw material in producing water treatment chemicals.
- → is used as an agricultural fungicide. For this use, it may require registration/authorisation to comply with local legal requirements on biocidal products.
- → is used for electroplating.
- → is used as an anti-oxidising agent.
- → is also used for preparation of dyes.

Dimethylamine is an important intermediate in the synthesis of a broad range of products, e.g. propellants, monomers, solvents, catalysts, insecticides, surfactants and ion-exchange resins.

Physical data

Molecular weight		45.084		
Boiling point	at 1.013 bar [°C]	6.88	at 14.5 psi [°F]	44.40
Density	at 1.013 bar, 15 °C [kg/m³]	1.965	at 1 atm., 70 °F [lb/ft³]	0.120
Vapour pressure	at 0 °C [bar]	0.74	at 32 °F [psi]	10.75
	at 20 °C [bar]	1.68	at 70 °F [psi]	25.47
Flammability range in air [% volume]		2.8 – 14.4		

2,2-Dimethylpropane C_5H_{12}

Neopentane

CAS: 463-82-1
EC: 207-343-7
UN: 2044

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® 2,2-dimethylpropane 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 1.2 bar(a)/70 °F: 7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with petrol like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas; **H411 –** Toxic to aquatic life with long lasting effects.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM OEM PETRO R&D

Source

2,2-Dimethylpropane can be isolated from the C5 mixture or derived from liquid components of natural gas or from light gasoline (naphtha). The separation is carried out either by molecular sieve separation or by super-fractionation and specific distillation.

Applications

2,2-Dimethylpropane is used as raw material in the production of iso-butene, which in turn is used to manufacture synthetic butyl rubber.

2,2-Dimethylpropane is used as a solvent and a synthesis intermediate.

2,2-Dimethylpropane is used as calibration standard for NMR (Nuclear Magnetic Resonance) spectroscopy.

2,2-Dimethylpropane is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight		72.15		
Boiling point	at 1.013 bar [°C]	9.5	at 14.5 psi [°F]	49.12
Density	at 1.013 bar, 15 °C [kg/m³]	3.193	at 1 atm., 70 °F [lb/ft³]	0.195
Vapour pressure	at 0 °C [bar]	0.71	at 32 °F [psi]	10.34
	at 20 °C [bar]	1.46	at 70 °F [psi]	21.93
Flammability range in air [% volume]		1.3 – 7.5		

Ethane C_2H_6

R-170

CAS: 74-84-0
EC: 200-814-8
UN: 1035
UN: 1961 (Refrigerated liquid)
R-170

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
Ethane 2.5	≥99.5 %	≤5,000
HiQ® Ethane 3.5	≥99.95 %	≤450

Typical filling pressure: 15 °C: 34 bar(a)/70 °F: 544 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, odourless, colourless gas. Gas density is slightly heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **Refrigerated Gas → H281 –** Contains refrigerated gas; may cause cryogenic burns or injury; **H220 –** Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F
3F (Refrigerated liquid)

DOT Class 2.1

AUTO CHEM CONSTR ENERGY MANUF METAL PETRO R&D

Source

The main commercial source of ethane is natural gas. Ethane is isolated either by absorption or by partial condensation, followed by distillation. Relatively small volumes of ethane are also gained as a by-product in oil refining processes.

Applications

The main industrial use for ethane is the production of ethene by steam-cracking.

It is commonly used as a raw material for the manufacture of halogenated ethane.

Ethane is used in the chemical industry for the production of ethanol, epoxyethane, glycol, acetaldehyde, ethenyl acetate, ethyl chloride, dichloroethane, styrene, polyethene, thermopolymers and higher alcohols.

Ethane is used as a refrigerant for extremely low temperature refrigeration systems. It has the ASHRAE number R-170.

Ethane is used in metallurgy for heat treatments.

Ethane is used as a calibration gas for combustion research.

Ethane is used as a component in calibration gases for the automotive, gas, oil and chemical industries.

Physical data

Molecular weight		30.07		
Boiling point	at 1.013 bar [°C]	−88.6	at 14.5 psi [°F]	−127.46
Density	at 1.013 bar, 15 °C [kg/m^3]	1.283	at 1 atm., 70 °F [lb/ft^3]	0.078
Vapour pressure	at 0 °C [bar]	23.87	at 32 °F [psi]	346.2
	at 20 °C [bar]	37.69	at 70 °F [psi]	559.92
Flammability range in air [% volume]		2.4 – 14.3		

Ethanedinitrile C_2N_2

Cyanogen, Oxalonitrile, EDN

CAS: 460-19-5
EC: 207-306-5
UN: 1026

Purity grade	Typical purity	Typical impurities [ppm]
Ethanedinitrile 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 4.2 bar(a)/70 °F: 58.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

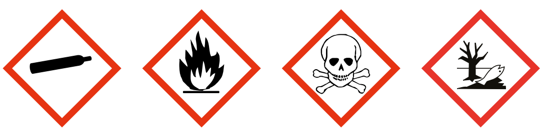
Colourless, liquefied gas with an odour of bitter almonds. Poor warning properties at low concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

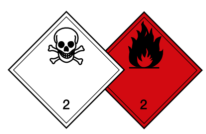
Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H330 – Fatal if inhaled; H410 – Very toxic to aquatic life with long lasting effects.

Transport of dangerous goods



ADR Class 2, 2TF

DOT Class 2.3

CHEM FOOD MANUF R&D

Source

Ethanedinitrile is typically generated from cyanide compounds. Alternatively, one can combine solutions of copper(II) salts (such as copper(II) sulfate) with cyanides. An unstable copper(II) cyanide is formed which rapidly decomposes into copper(I) cyanide and ethanedinitrile.

Industrially, it is made by the oxidation of hydrogen cyanide, usually using chlorine over an activated silicon dioxide catalyst or nitrogen dioxide over a copper salt. It is also formed when nitrogen (N_2) and acetylene (C_2H_2) are forced to react by an electrical spark or discharge.

Applications

Ethanedinitrile has a long history and was probably first generated by Carl Scheele around 1782 in the course of his studies of hydrogen cyanide. The first confirmed synthesis was reported in 1802, when it was used to make what we now know as cyanic chloride (cyanogen chloride). It attained importance with the growth of the fertiliser industry in the late nineteenth century.

Ethanedinitrile is used as a stabiliser in the production of nitrocellulose.

Ethanedinitrile is used as a fumigant for a number of applications; it has a better efficacy and allows faster replanting when compared to other fumigants.

Ethanedinitrile may require registration/authorisation to comply with local legal requirements on pesticides/biocides.

Ethanedinitrile is also used for special welding, due to the second highest known flame temperature (4,527°C, 8,180°F) when it burns in oxygen.

Ethanedinitrile is an important intermediate in the production of many fertilisers.

Physical data

Molecular weight		52.035		
Boiling point	at 1.013 bar [°C]	−21.2	at 14.5 psi [°F]	−6.14
Density	at 1.013 bar, 15 °C [kg/m³]	2.24	at 1 atm., 70 °F [lb/ft³]	0.140
Vapour pressure	at 0 °C [bar]	2.44	at 32 °F [psi]	35.35
	at 20 °C [bar]	4.90	at 70 °F [psi]	73.58
Flammability range in air [% volume]		3.9 – 36.6		

Ethyl chloride C_2H_5Cl

Chloroethane

CAS: 75-00-3
EC: 200-830-5
UN: 1037
R-160

Purity grade	Typical purity	Typical impurities [ppm]	
		H_2O	Acidity (as HCl)
HiQ® Ethyl chloride 3.0	≥99.9 %	≤100	≤10

Typical filling pressure: 15 °C: 1.1 bar(a)/70 °F: 20.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with an ethereal odour. Poor warning properties at low concentrations. Gas density is heavier than air.

GHS-CLP

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas; **H351 –** Suspected of causing cancer; **H412 –** Harmful to aquatic life with long lasting effects.

ADR Class 2, 2F

DOT Class 2.1

CHEM CONSTR MANUF MEDICAL PETRO R&D

Source

Ethyl chloride is produced by the reaction of chlorine on ethene in the presence of chlorides of copper, iron, antimony and calcium.

Ethyl chloride can also be prepared photochemically by the reaction of chlorine and ethene in the presence of light and hydrogen chloride.

Some Ethyl chloride is generated as a by-product of polychloroethene production.

Applications

Ethyl chloride has been used as a foaming agent, anaesthetic, refrigerant and propellant, and in tetraethyl lead manufacturing.

Ethyl chloride is used as an alkylating agent. Ethyl chloride is used as an intermediate in organic synthesis.

Ethyl chloride is used industrially in treating cellulose to make ethyl cellulose, a thickening agent and binder in paints, cosmetics and similar products.

Physical data

Molecular weight		64.514		
Boiling point	at 1.013 bar [°C]	12.27	at 14.5 psi [°F]	54.09
Density	at 1.013 bar, 15 °C [kg/m^3]	2.819	at 1 atm., 70 °F [lb/ft^3]	0.176
Vapour pressure	at 0 °C [bar]	0.62	at 32 °F [psi]	9.03
	at 20 °C [bar]	1.34	at 70 °F [psi]	20.25
Flammability range in air [% volume]		3.6 – 14.8		

Ethyl formate $C_3H_6O_2$

CAS: 109-94-4
EC: 203-721-0
UN: 1190

Purity grade	Typical purity	Typical impurities [ppm]
Ethyl formate 2.0	≥99 %	contact local team

Typical filling pressure: Filled as liquid

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable, colourless liquid with distinct and alcoholical odour. Heavier than air. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER


H-statements:
H225 – Highly flammable liquid and vapour; **H332** – Harmful if inhaled; **H302** – Harmful if swallowed; **H319** – Causes serious eye irritation; **H335** – May cause respiratory irritation.

Transport of dangerous goods

ADR Class 3, F1

DOT Class 3

CHEM FOOD MANUF PHARMA R&D

Source

The main method is the conversion of ethanol and formic acid in the presence of a catalyst like sulfuric acid. The water formed is extracted on a continuous basis off the formed ethyl formate.

Applications

Ethyl formate is used as a flavouring for lemonade and essences, it has a typical smell associated with rum. Ethyl formate is considered to be a GRAS (= generally considered as safe) additive by the EPA.

In industry, it is used as a solvent for cellulose nitrate, cellulose acetate, oils and greases. It can be used as a solvent to substitute acetone, for example. In the pharmaceutical industry, it is widely used as a fragrance and it is used in chemical synthesis as an intermediate.

Ethyl formate can be used as a fumigant for dried fruits, tobacco, cereals, fresh fruit, cut flowers and many more. For such use it may require registration/authorisation to comply with local legal requirements on pesticides/biocides. Blends of ethyl formate are registered in countries like Australia and the Philippines for this application.

Physical data

Molecular weight		74.09		
Boiling point	at 1.013 bar [°C]	53.00	at 14.5 psi [°F]	12.90
Density	at 1.013 bar, 15 °C [kg/m^3]	916.80	at 1 atm., 70 °F [lb/ft^3]	57.23
Vapour pressure	at 0 °C [bar]	0.0961	at 32 °F [psi]	1.39
	at 20 °C [bar]	0.256	at 70 °F [psi]	3.7
Flammability range in air [% volume]		2.6 – 18.2		

Ethylamine $(C_2H_5)NH_2$

Ethanamine, Aminoethane

CAS: 75-04-7
EC: 200-834-7
UN: 1036

Purity grade	Typical purity	Typical impurities [ppm]
Ethylamine 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 0.9 bar(a) /70 °F: 2.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with strong ammonia/rotten fish-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H332** – Harmful if inhaled; **H319** – Causes serious eye irritation; **H335** – May cause respiratory irritation.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO PHARMA R&D

Source

Ethylamine is produced industrially from ethanol/bio ethanol and ammonia with the help of an oxide catalyst. In a subsequent purification step it may be separated from the co-produced diethyl amine and triethyl amine.

An alternative reaction path uses the reductive amination of acetaldehyde.

Ethylamine is further prepared in a reaction of ethyl iodide and liquid ammonia.

Applications

Ethylamine is widely used in organic chemistry as a reactive molecule or precursor in many syntheses.

Ethylamine:

- → is used as a solvent in lithium chemistry.
- → is used as a stabiliser for rubber latex.
- → is used as an intermediate in dye stuff.
- → is used as an intermediate in pharma production.

Ethylamine is a major precursor in herbicide production.

Ethylamine is used to produce flotation agents, mining chemicals and as a chain stopper in the production of polyurethane.

Physical data

Molecular weight		45.084		
Boiling point	at 1.013 bar [°C]	16.58	at 14.5 psi [°F]	61.86
Density	at 1.013 bar, 15 °C [kg/m^3]	1.970	at 1 atm., 70 °F [lb/ft^3]	0.120
Vapour pressure	at 0 °C [bar]	0.49	at 32 °F [psi]	7.10
	at 20 °C [bar]	1.15	at 70 °F [psi]	17.45
Flammability range in air [% volume]		3.5 – 13.9		

Ethylene C_2H_4

Ethene

CAS: 74-85-1
EC: 200-815-3
UN: 1962
UN: 1038 (Refrigerated liquid)
R-1150

Purity grade	Typical purity	Typical impurities [ppm]		
		O_2	N_2	Other C_nH_m
Ethylene 3.0	≥99.9 %	≤30	≤150	≤1100
HiQ® Ethylene 3.5	≥99.95 %	≤15	≤50	≤450

Typical filling pressure: 15 °C: 76 bar(a)/ 70 °F: 1,200 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless gas with slight odour. Gas density is slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **Refrigerated Gas** → **H281** – Contains refrigerated gas; may cause cryogenic burns or injury; **H220** – Extremely flammable gas; **H336** – May cause drowsiness or dizziness.

Transport of dangerous goods

ADR Class 2, 2F
3F (Refrigerated liquid)

DOT Class 2.1

AUTO CHEM CONSTR FOOD MANUF MEDICAL PETRO R&D

Source

Ethylene is mainly produced in chemical refineries by different cracking processes depending on the raw material/product stream used. In this process, heavier hydrocarbons are broken up at high temperature to form C_2 and C_3 hydrocarbons, mainly unsaturated ethylene. Combined compression and distillation steps yield pure ethylene.

Smaller volumes of ethylene are produced by passing ethyl alcohol vapours over dehydrating catalysts at 360–470°C.

Ethylene may also be produced by the pyrolysis of ethane.

Applications

Ethylene is the starting material for many industrial syntheses. It is employed as an intermediate in the chemical industry and for the production of a huge variety of plastics.

Ethylene is used for the production of many major chemicals:

- acetaldehyde
- acetic acid
- chloroethene (vinyl chloride)
- dichloroethane
- 1,1-dichloroethene (vinylidene chloride)
- epoxyethane (ethylene oxide)
- ethanediol (ethylene glycol)
- ethanol
- ethoxyethane
- ethyl chloride
- ethylbenzene
- phenylethene (styrene)
- polychloroethene (polyvinyl chloride)
- polyethene
- propanoic acid
- tetraethyl lead
- trichloroethane

Ethylene is used as a component in calibration gases for the automotive, gas, oil and chemical industries.

Ethylene may be employed for welding and cutting, but it is not used for this purpose industrially.

Ethylene is used for controlled ripening of fruit, especially bananas. Concentrations of a few ppm only are used in warehouse atmospheres. Because of flammability considerations, it is strongly recommended to use a mixture of ethylene in nitrogen in this application. Ethylene may require registration/authorisation to comply with local legal requirements on plant protection/growth regulator products.

Ethylene has also been used in agriculture to promote crop growth: in these cases the gas is injected directly into the soil.

Ethylene is still used as an anaesthetic (in the US). Ethylene for this purpose may be classified as a medical gas in some geographies and managed according to the relevant regulation.

Ethylene is used as a refrigerant, especially in the petrochemical industry. It has the ASHRAE number R-1150.

Physical data

Molecular weight		28.054		
Boiling point	at 1.013 bar [°C]	−103.68	at 14.5 psi [°F]	−154.60
Density	at 1.013 bar, 15 °C [kg/m^3]	1.194	at 1 atm., 70 °F [lb/ft^3]	0.073
Vapour pressure	at 0 °C [bar]	40.95	at 32 °F [psi]	593.9
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		2.4 – 32.6		

Ethylene Oxide C_2H_4O

Epoxyethane, Oxirane

CAS: 75-21-8
EC: 200-849-9
UN: 1040

Purity grade	Typical purity	Typical impurities [ppm]	
		H_2O	CO_2
HiQ® Ethylene oxide 3.0	≥99.9 %	≤200 %(w)	≤200

Typical filling pressure: 15 °C: 1.2 bar(a)/70 °F: 50 psi(g) normally pressurised with nitrogen at 6-7 bar

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Odourless and colourless gas. Heavier than air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

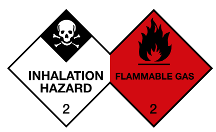
Signal word: DANGER

H-statements:

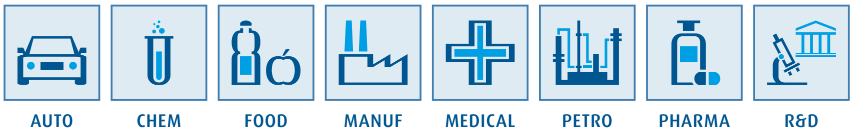
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H230 – May react explosively even in absence of air; H350 – May cause cancer; H340 – May cause genetic defects; H331 – Toxic if inhaled; H319 – Causes serious eye irritation; H335 – May cause respiratory irritation; H315 – Causes skin irritation.

Transport of dangerous goods

ADR Class 2, 2TF



DOT Class 2.3



Source
Ethylene oxide is usually manufactured by direct oxidation of ethylene using oxygen at high temperature in the presence of silver catalysts.

Applications
The main use of ethylene oxide is in the manufacture of ethene glycol (ethylene glycol) and higher alcohols which find important applications in automotive antifreeze.

Other main chemical products synthesised are glycol ethers, ethanolamines, ethoxylates and acrylonitriles. Typical uses are as solvents and in the production of scrubber fluids, surfactants and synthetic rubber.

It is also used in the production of explosives, cellophane, detergents, lubricants and hydraulic fluids.

As a pharmaceutical intermediate, ethylene oxide is used in the synthesis of choline, thiamine and procaine.

Ethylene oxide may be used as a fumigant by applying EtO mixtures with either carbon dioxide or halocarbon propellants. Its use for such applications may be restricted in many geographies, e.g. EtO is banned as a pesticide in the EU. Thus EtO may require registration/authorisation to comply with local legal requirements on biocidal products.

Ethylene oxide is widely used as a sterilisation agent for medical devices. Typical products sterilised with ethylene oxide are: medicine bottles, food containers, disposable nappies, sanitary towels, packaged sterile medical devices, surgeons gloves and instruments, first aid bandages, etc.

Ethylene oxide is used in fermentation processes and in the preparation of antibiotics.

Note:
Ethylene oxide is listed in the Rotterdam Convention. There may be import/export restrictions.

Physical data

Molecular weight		44.053		
Boiling point	at 1.013 bar [°C]	10.45	at 14.5 psi [°F]	50.81
Density	at 1.013 bar, 15 °C [kg/m^3]	1.91	at 1 atm., 70 °F [lb/ft^3]	0.117
Vapour pressure	at 0 °C [bar]	0.66	at 32 °F [psi]	9.61
	at 20 °C [bar]	1.47	at 70 °F [psi]	22.1
Flammability range in air [% volume]		2.6 – 100		

Fluorine F_2

CAS: 7782-41-4
EC: 231-954-8
UN: 1045

Purity grade	Typical purity	Typical impurities [ppm]	
		HF	$N_2 + O_2$
Fluorine 1.8	≥98 %	≤5,000	≤10,000

Typical filling pressure: 15 °C: 28.6 bar(a)/70 °F: 398.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

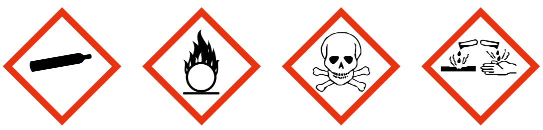
Pale yellow gas with sharp odour. Ignites most organic materials and metals. Highly corrosive. See comprehensive handling directives. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

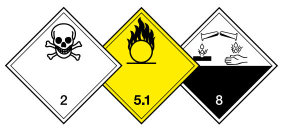
Signal word: DANGER



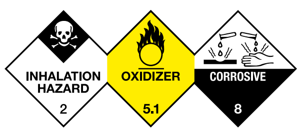
H-statements:

Compressed Gas → **H280** – Contains gas under pressure; may explode if heated; **H270** – May cause or intensify fire; oxidiser; **H330** – Fatal if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TOC



DOT Class 2.3

AUTO CHEM MANUF METAL PETRO R&D SEMI

Source

Fluorine is produced by electrolysing a solution of potassium fluoride and anhydrous hydrogen fluoride at elevated temperature.

Applications

The primary use for fluorine is in the refining of uranium. During the process, fluorine reacts with uranium to produce uranium hexafluoride, which may then be purified in the gaseous state before being converted back to uranium.

Fluorine is also required in the production of a variety of fluorinated compounds such as sulfur hexafluoride, boron trifluoride and metal fluorides. Fluorine is used in HF/DF chemical lasers.

Fluorine and graphite heated generate carbon monofluoride (graphite fluoride), which is used as a dry lubricant or as a material for electrodes.

Fluorine is used for fluorination in the production of:
→ fluorinated hydrocarbons (Freon®, Forane®, etc.) and plastics (Teflon®, Kel-F®, etc.)
→ fluorosilicates used to opacify and reduce the viscosity of certain glasses
→ perfluoro acids used to obtain wetting agents
→ inorganic fluorinated compounds such as tungsten hexafluoride used for metal coatings, iodine pentafluoride used in the manufacture of special fabrics and antimony pentafluoride used to replace tetraethyl lead in automobile fuels.

When diluted to a concentration of about 1% in nitrogen, fluorine is used during the blow moulding of polyethylene containers to create an impervious barrier on the inner walls of the blown vessels. These containers are then more suitable for storage of solvents or other chemicals.

Fluorine is used for chamber cleaning in the semiconductor industry.

Physical data

Molecular weight		37.997		
Boiling point	at 1.013 bar [°C]	−188.2	at 14.5 psi [°F]	−306.74
Density	at 1.013 bar, 15 °C [kg/m³]	1.608	at 1 atm., 70 °F [lb/ft³]	0.098
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Fluoromethane CH_3F

Methyl fluoride, HFC-41, R-41

CAS: 593-53-3
EC: 209-796-6
UN: 2454
R-41

Purity grade	Typical purity	Typical impurities [ppm]		
		H_2O	O_2	N_2
Fluoromethane 2.5	≥99.5 %	≤100	≤1,200	≤3,600

Typical filling pressure: 15 °C: 29.55 bar(a)/70 °F: 485.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, colourless gas with a sweet odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CONSTR MANUF R&D SEMI

Source

Fluoromethane is prepared by heating fluorosulfonic acid methyl ester with potassium fluoride.

Fluoromethane is produced industrially by catalytically reacting ethane and hydrogen fluoride in the presence of aluminium trichloride.

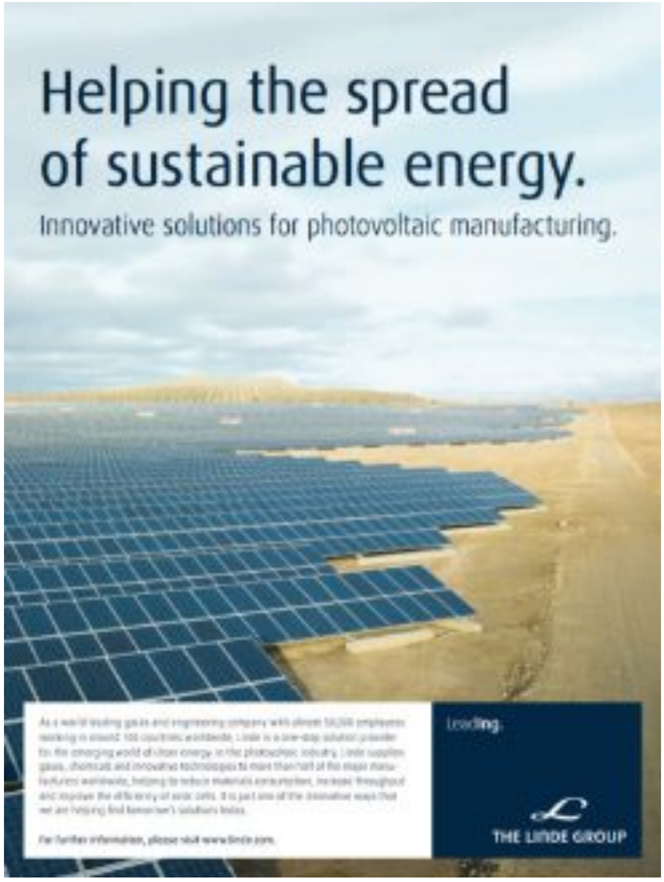
Applications

Fluoromethane is used in plasma etching of silicon compound films in semiconductor manufacturing.

Fluoromethane has been used as a refrigerant and was previously used as a propellant.

Note:

Fluoromethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.



Physical data

Molecular weight		34.03		
Boiling point	at 1.013 bar [°C]	−78.4	at 14.5 psi [°F]	−109.1
Density	at 1.013 bar, 15 °C [kg/m³]	1.452	at 1 atm., 70 °F [lb/ft³]	0.089
Vapour pressure	at 0 °C [bar]	19.80	at 32 °F [psi]	287.2
	at 20 °C [bar]	33.56	at 70 °F [psi]	500.5
Flammability range in air [% volume]		5.6 – 22.2		

Helium He

CAS: 7440-59-7
EC: 231-168-5
UN: 1046 (Compressed)
UN: 1963 (Refrigerated liquid)
R-704

Legend: N/D = Not Detectable

Purity grade	Purity	Impurities [ppm] H_2O	O_2	C_nH_m	CO	CO_2	N_2	H_2	$O_2 + N_2$	CH_4	Odour	Halocarbons
HiQ® Helium 4.6	≥99.996 %	≤5	≤5	-	-	-	-	-	-	-	-	-
HiQ® Helium 5.0	≥99.999 %	≤3	≤2	≤0.5	-	-	≤5	-	-	-	-	-
HiQ® Helium 5.0 Zero	≥99.999 %	≤3	≤2	≤0.2	≤1	≤1	≤5	-	-	-	-	-
HiQ® Helium 5.5 ECD	≥99.9995 %	≤1	≤1	≤0.1	≤0.5	≤0.5	≤2	-	-	-	-	≤1 ppb
HiQ® Helium 6.0	≥99.9999 %	≤0.5	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	≤0.5	-	-	-	-
HiQ® Helium 7.0	≥99.99999 %	≤50 ppb	≤30 ppb	≤30 ppb	≤30 ppb	≤30 ppb	-	≤30 ppb	-	-	-	≤1 ppb
VERISEQ® Process Helium (pharmaceutical grade)	≥99.5 %	≤67	≤50	-	≤10	-	-	-	≤10,000	≤50	N/D	-

Typical filling pressure: 15 °C: 200 bar(a)/70 °F: 2,640 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•		Cryogenic liquid	•	

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•	Cryogenic liquid	Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Asphyxiant in high concentrations. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: WARNING

H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; **Refrigerated Gas → H281 –** Contains refrigerated gas; may cause cryogenic burns or injury; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 1A (Compressed)
3A (Refrigerated liquid)

DOT Class 2.2

AUTO CONSTR ENERGY MANUF MEDICAL METAL OEM R&D SEMI

Source

The primary source of helium is from natural gas wells. It is obtained by a liquefaction and stripping operation.

Due to the world shortage in helium, many applications have recovery systems to reclaim the helium.

Applications

Helium is inert and the least soluble of all gases in liquids and is therefore used as a pressurisation gas for:

- cryogenic rocket propellants in space/missile applications
- heavy water in nuclear reactors
- for all liquids at room or low temperatures.

Helium is added to neutral atmospheres, e.g. in heat treatment applications requiring a protective atmosphere.

Helium is used extensively in the welding industry as an inert shielding gas for arc welding. It is also used in conjunction with helium (“leak”) detectors to test the integrity of fabricated components and systems.

Various mixtures of helium and oxygen are used as breathing gases for divers who must work at great depths and therefore high pressures. The use of helium to dilute the oxygen instead of nitrogen, as in air, prevents nitrogen being dissolved in the blood, which is the cause of nitrogen narcosis (also known as “bends”).

Helium is used to fill large balloons for upper atmosphere and cosmic ray studies. Small helium balloons are used by weather forecasters to carry meteorological instruments.

Due to nonflammability and low density, this gas is ideal for filling toy balloons (in mixtures with nitrogen), airplane tyres, advertising blimps, geostationary balloons (certain projects are under way for the realisation of balloons designed to serve as television transmission and observation relays).

Helium mixtures with hydrocarbons are used in flushing Geiger counters used for the detection of ⟨α, β, γ and X-rays.

Helium is used as a carrier gas or as a purge gas for a variety of semiconductor processes.

Helium is used as a calibration and balance gas in calibration mixtures, a carrier gas in gas chromatography and purge and zero (span) gas for analytical instruments.

Helium is used:

- as a combined cooling and shielding medium for the pulling of optical fibres.
- for cooling uranium rods in nuclear reactors.
- in various types of gas lasers as a buffer or carrier gas.
- in mixtures with neon and argon for filling electronic tubes such as the familiar neon sign.
- for epitaxial crystal growth (inert atmosphere).
- for vacuum breaking in heat treatment furnaces.
- as an airbag inflating gas in high-pressure capsules.
- to create inert furnace atmospheres in special glass processing and valuable metals applications.

Liquid helium is used to cool the superconductive magnets in NMR (Nuclear Magnetic Resonance) for analytical or medical purposes and in the R&D to study processes around absolute Zero.

Physical data

Molecular weight		4.003		
Boiling point	at 1.013 bar [°C]	−268.93	at 14.5 psi [°F]	−452.05
Density	at 1.013 bar, 15 °C [kg/m^3]	0.169	at 1 atm., 70 °F [lb/ft^3]	0.010
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

1,1,1,2,3,3,3-Heptafluoropropane C_3HF_7

HFC-227ea, R-227ea

CAS: 431-89-0
EC: 207-079-2
UN: 3296
R-227ea

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
1,1,1,2,3,3,3-Heptafluoropropane	≥99.9 %	≤10 ppm(w)

Typical filling pressure: 15 °C: 3.3 bar(a)/70 °F: 58.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with an ethereal smell and slight odour warning effect at low concentration. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

H280 - Contains gas under pressure; may explode if heated.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CHEM CONSTR FOOD MEDICAL PETRO PHARMA

Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for 1,1,1,2,3,3,3-heptafluoropropane uses hexafluoropropene (HFC-236fa) which is reacted with HF in an inert gas.

Applications

1,1,1,2,3,3,3-heptafluoropropane (HFC-227ea) can be used as a refrigerant, a propellant (especially in medical applications) and as a fire suppressant.

Note:

1,1,1,2,3,3,3-heptafluoropropane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		170.03		
Boiling point	at 1.013 bar [°C]	-17.3	at 14.5 psi [°F]	0.86
Density	at 1.013 bar, 15 °C [kg/m³]	7.3525	at 1 atm., 60 °F [lb/ft³]	0.4590
Vapour pressure	at 0 °C [bar]	1.95	at 32 °F [psi]	28.3
	at 20 °C [bar]	3.99	at 70 °F [psi]	58.6
Flammability range in air [% volume]		Not combustible		

Hexafluoroethane C_2F_6

Perfluoroethane, FC-116, R-116

CAS: 76-16-4
EC: 200-939-8
UN: 2193
R-116

Purity grade	Typical purity	Typical impurities [ppm]					
		H_2O	$O_2 + N_2$	CO	CO_2	Other Halocarbons	Acidity
HiQ® Hexafluoroethane 2.8	≥99.8 %	-	-	-	-	-	-
HiQ® Hexafluoroethane 3.5	≥99.95 %	≤5	≤300	-	-	≤200	≤1 %(w)
HiQ® Hexafluoroethane 5.0	≥99.999 %	≤1	≤5	≤1	≤1	≤5	≤0.1 %(w)

Typical filling pressure: 15 °C: 27 bar(a)/70 °F: 375.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless, odourless, liquefied gas. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: **WARNING**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CHEM CONSTR ENERGY MANUF PETRO R&D SEMI

Source
Hexafluoroethane may be obtained as a by-product of CFC production, or by direct fluorination of ethane.

Applications
Hexafluoroethane may be used as a raw material for the production of monomers. In chemical synthesis it is employed to introduce fluorine into molecules.

Hexafluoroethane is used in electrical and electronic equipment as a gaseous dielectric.

Hexafluoroethane is used for dry etching of silicon dioxide on silicon and for stripping photoresists in semiconductor production.

Hexafluoroethane (R-116) is used as a refrigerant in certain low-temperature applications as well as a component in a few refrigerant blends.

Hexafluoroethane is used as a propellant, very often functioning as a gaseous insulator in foams.

Note:
Hexafluoroethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		138.01		
Boiling point	at 1.013 bar [°C]	−78.2	at 14.5 psi [°F]	−108.74
Density	at 1.013 bar, 15 °C [kg/m^3]	5.912	at 1 atm., 70 °F [lb/ft^3]	0.361
Vapour pressure	at 0 °C [bar]	18.64	at 32 °F [psi]	270.3
	at 20 °C [bar]	30.01	at 70 °F [psi]	435.3
Flammability range in air [% volume]		Non combustible		

1,1,1,3,3,3-Hexafluoropropane $C_3H_2F_6$

HFC-236fa, R-236fa

CAS: 690-39-1
EC: 425-320-1
UN: 3163
R-236fa

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
1,1,1,3,3,3-Hexafluoropropane	≥99.99 %	≤10 ppm(w)

Typical filling pressure: 25 °C: 2.7 bar(a)/77 °F: 39.2 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with a slight ether-like smell. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

H280 - Contains gas under pressure; may explode if heated.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CHEM CONSTR FOOD PETRO

Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. One synthesis route for 1,1,1,3,3,3-hexafluoropropane involves using 1,1,1,3,3,3-hexachloropropane reacted with HF using a chromium catalyst.

Applications

1,1,1,3,3,3-hexafluoropropane (HFC-236fa) has a wide range of niche applications. These include as a fire suppression agent, a foaming agent and a refrigerant or heat transfer fluid.

Note:

1,1,1,3,3,3-hexafluoropropane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		152.04		
Boiling point	at 1.013 bar [°C]	-2.0	at 14.5 psi [°F]	28.4
Density	at 1.013 bar, 22.4 °C [kg/m³]	6.18	at 1 atm., 72.3 °F [lb/ft³]	0.3558
Vapour pressure	at 0 °C [bar]	1.59	at 32 °F [psi]	23.1
	at 25 °C [bar]	2.7	at 77 °F [psi]	39.2
Flammability range in air [% volume]		Not combustible		

Hydrogen H_2

CAS: 1333-74-0
EC: 215-605-7
UN: 1049 (Compressed)
UN: 1966 (Refrigerated liquid)
R-702

Purity grade	Purity	Impurities [ppm]						
		H_2O	O_2	C_nH_m	CO	CO_2	N_2	Halocarbons
HiQ® Hydrogen 4.6	≥99.996 %	≤5	≤5	-	-	-	-	-
HiQ® Hydrogen 5.0	≥99.999 %	≤3	≤2	≤0.5	-	-	≤5	-
HiQ® Hydrogen 5.0 Zero	≥99.999 %	≤3	≤2	≤0.2	≤1	≤1	≤5	-
HiQ® Hydrogen 5.5 ECD	≥99.9995 %	≤1	≤1	≤0.1	≤0.5	≤0.5	-	≤1 ppb
HiQ® Hydrogen 6.0	≥99.9999 %	≤0.5	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	-
HiQ® Hydrogen 7.0	≥99.99999 %	≤50 ppb	≤30 ppb	≤30 ppb	≤30 ppb	≤30 ppb	-	-

Typical filling pressure: 15 °C: 200 bar(a)/ 70 °F: 2,400 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•			•	

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Odourless and colourless gas. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H220 – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 1F (Compressed)
3F (Refrigerated liquid)

DOT Class 2.1

CHEM ENERGY FOOD MANUF METAL OEM PETRO PHARMA R&D SEMI

Source

Hydrogen is most frequently produced for on-site usage by steam reforming of natural gas. Such plants may also be used as sources of hydrogen for the merchant market. Other sources are the chlor-alkali process that electrolyses sodium chloride solution to produce chlorine, and various waste gas recovery plants, such as at oil refineries or steel plants (coke oven gas). Hydrogen is also produced by electrolysis of water.

Applications

High-purity hydrogen finds widespread usage in the electronics industry as a reducing agent and as a carrier gas.

High-purity hydrogen is used as a carrier gas in gas chromatography.

Hydrogen finds some usage in the welding and cutting of metals.

Hydrogen is used in large quantities, (bulk supply or on- site generation) for the hydrogenation of vegetable and animal oils to produce margarine and other fats, hydro- treatment of petroleum products, and hydrosulfuration of fuels in order to eliminate sulfur.

Hydrogen in large quantities is used in petrochemical processes that include hydrodealkylation, hydrodesulfurisation, hydrotreatment.

Hydrogen is used in leak testing applications.

Hydrogen is used in HF/DF chemical lasers (see page 121).

Hydrogen is used extensively in the metals industries because of its ability to reduce metal oxides and prevent oxidation of metals during heat treatment. It may be used either pure, as is often the case when heat treating stainless steel, or in a mixture with inert gases, argon or nitrogen. It is used in the production of carbon steels, special metals and semiconductors.

Hydrogen is used for combustion;
- → in industry, it is used to supply oxygen-hydrogen torches for glass working (quartz, Pyrex®, etc), in the fabrication of artificial precious stones (ruby, etc), and for under water oxycutting
- → in the laboratory, it is used in analyzer flames, reducing flame photometry detection instruments, flame ionisation detection instruments, and fuel cells.

Extremely pure hydrogen is used in the chemical industry for fine reduction processes.

Liquefied hydrogen is used as a rocket fuel. In the laboratory liquid hydrogen is employed for solid physics research.

In the nuclear industry para-hydrogen is employed to fill bubble chambers.

In electrical power plants hydrogen is used as a coolant gas in turbogenerators.

Hydrogen is used for synthesis of ammonia.

Hydrogen is used as a reagent to produce high-purity water.

Hydrogen is used as fuel in fuel cell applications.

Hydrogen is used as component in gas mixtures.

Physical data

Molecular weight		2.016		
Boiling point	at 1.013 bar [°C]	−252.76	at 14.5 psi [°F]	−422.95
Density	at 1.013 bar, 15 °C [kg/m³]	0.0852	at 1 atm., 70 °F [lb/ft³]	0.005
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		4.0 – 77.0		

Hydrogen bromide HBr

CAS: 10035-10-6
EC: 233-113-0
UN: 1048

Purity grade	Typical purity	Typical impurities [ppm]								
		HCl	H_2O	O_2	N_2	CO	CO_2	C_nH_m	CH_4	Fe
HiQ® Hydrogen bromide 2.8	≥99.8 %	≤2,000	-	-	-	-	-	-	-	-
HiQ® Hydrogen bromide 4.5	≥99.995 %	-	≤5	≤3	≤10	≤1	≤20	≤10	-	≤1 %(w)
HiQ® Hydrogen bromide 5.0	≥99.999 %	-	≤1	≤1	≤2	≤1	≤5	-	≤1	≤1 %(w)

Typical filling pressure: 15 °C: 19 bar(a)/70 °F: 320 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Highly corrosive. Liquefied gas with pungent odour. Forms white fumes in humid air. Highly corrosive under humid conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

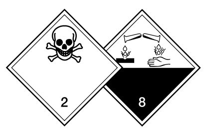
GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H331** – Toxic if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM MANUF PETRO PHARMA R&D SEMI

Source

Hydrogen bromide is obtained as a by-product during the bromination of organic compounds such as methyl bromide.

Applications

Hydrogen bromide is used both as a reagent and as a catalyst in a variety of organic reactions. It is also used for the preparation of numerous inorganic bromides.

Hydrogen bromide is also used for hydrobromination in the chemical and pharmaceutical industries.

Hydrogen bromide is used in the production process of lamps (so called "iodine" automobile headlights, electrostatic photocopy machine lamps, etc.).

Hydrogen bromide is used in the manufacturing of semiconductor components as an etchant.

Physical data

Molecular weight		80.912		
Boiling point	at 1.013 bar [°C]	−66.7	at 14.5 psi [°F]	−88.04
Density	at 1.013 bar, 15 °C [kg/m³]	3.45	at 1 atm., 70 °F [lb/ft³]	0.211
Vapour pressure	at 0 °C [bar]	13	at 32 °F [psi]	187.9
	at 20 °C [bar]	21.8	at 70 °F [psi]	324.57
Flammability range in air [% volume]		Non combustible		

Hydrogen chloride HCl

CAS: 7647-01-0
EC: 231-595-7
UN: 1050

Purity grade	Typical purity	Typical impurities [ppm]						
		H_2O	O_2	N_2	CO	CO_2	C_nH_m	Fe
Hydrogen chloride 3.0	≥99.9 %	≤10	-	-	-	-	-	-
HiQ® Hydrogen chloride 4.5	≥99.995 %	≤2	≤5	≤10	≤2	≤40	≤2	-
HiQ® Hydrogen chloride 5.0	≥99.999 %	≤2	≤1	≤4	≤1	≤3	≤1	≤1
HiQ® Hydrogen chloride 5.5	≥99.9995 %	≤1	≤0.5	≤1	≤0.5	≤1	≤0.5	≤0.1

Typical filling pressure: 15 °C: 37 bar(a)/ 70 °F: 613 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas with pungent odour. Forms white fumes in humid air. Corrosive in humid conditions. Gas density is heavier than air.

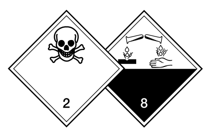
Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H331** – Toxic if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM MANUF METAL PETRO PHARMA R&D SEMI

Source

Hydrogen chloride is usually prepared in commercial quantities by the direct combination of chlorine and hydrogen. This is achieved by "burning" chlorine in an atmosphere of hydrogen. Most of the hydrogen chloride produced in this way is dissolved directly in water to produce hydrochloric acid. Lesser quantities are collected as anhydrous hydrogen chloride, especially for use in the semiconductor industry and pharmaceutical production.

Applications

Hydrogen chloride is used to remove the remaining fibres from cotton seeds after the cotton wool has been separated and before the seed is stored for resowing next season. Hydrogen chloride is also used in separating cotton from wood.

Hydrogen chloride is used in the manufacture of inorganic chlorides.

Hydrogen chloride is used as chlorine donor in excimer lasers.

Hydrogen chloride is used to promote and regenerate catalysts in the petrochemical industry and in lubricants/oil production to add viscosity to oils.

Hydrogen chloride is used for hydrochlorination (e.g. production of methyl chloride) and oxychlorination (e.g. production of chloroethene). It is also employed to produce chlorosulfonic acid and synthetic rubbers.

Hydrogen chloride is used as a thermal etchant in the semiconductor industry to remove material from unmasked areas, thus preparing wafer surfaces for epitaxial deposition.

High-purity hydrogen chloride gas is widely used in the electronics industry. It is a chlorine carrier produced by high-temperature cracking. It is used in the following applications:

- → scouring furnaces (quartz chambers)
- → dissolved in water as an aqueous cleaning agent to prepare metal surfaces for electroplating
- → selective etching of windows in electronic microcircuits
- → carrier for non-volatile elements in the form of gaseous chloride.

Hydrogen chloride is used as a reactive agent in pharmaceutical synthesis.

Hydrogen chloride is also used for production of hard metals.

Physical data

Molecular weight		36.461		
Boiling point	at 1.013 bar [°C]	–85.1	at 14.5 psi [°F]	–120.98
Density	at 1.013 bar, 15 °C [kg/m^3]	1.552	at 1 atm., 70 °F [lb/ft^3]	0.095
Vapour pressure	at 0 °C [bar]	25.6	at 32 °F [psi]	371.1
	at 20 °C [bar]	42.02	at 70 °F [psi]	625.37
Flammability range in air [% volume]		Non combustible		

Hydrogen cyanide HCN

Hydrocyanic acid

CAS: 74-90-8
EC: 200-821-6
UN: 1051

Purity grade	Typical purity	Typical impurities [ppm]
		H_2SO_4 or H_3PO_4 (Stabiliser)
HiQ® Hydrogen cyanide 2.0 (stabilised)	≥99.9 %	≤0.95

Typical filling pressure: 20°C: 0.83 bar(a)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics
Flammable. Colourless gas with the characteristic odour of bitter almonds. Slightly lighter than air.

Hazard classifications

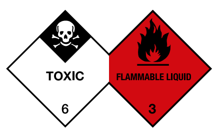
Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
H224 – Extremely flammable liquid and vapour; **H330 –** Fatal if inhaled; **H331 –** Fatal in contact with skin; **H410 –** Very toxic to aquatic life with long lasting effects.

Transport of dangerous goods

ADR Class 6.1, TF1



DOT Class 6.1

CHEM FOOD MANUF OEM PHARMA R&D

Source

The main method of manufacturing hydrogen cyanide is by reacting methane, ammonia and air over a platinum catalyst at 1,000-2,000°C.

Many fruits with a pit such as almonds, apples and apricots contain small levels of HCN.

Applications

The largest use is in the manufacture of acrylonitrile, but it is also used in the manufacture of methyl methacrylate, adiponitrile (for nylon), as a precursor in the production of sodium and potassium cyanide and last but not least in generating ferrocyanides.

Hydrogen cyanide is an important raw material in the chemical industry, helping to synthesise a large family of fluorine-containing molecules.

HCN is used as a component in calibration gases for environmental control of coal fired power plants.

HCN is also used as a fumigant in certain geographies. HCN may require registration/authorisation to comply with local legal requirements on pesticides/biocides.

Physical data

Molecular weight		27.03		
Boiling point	at 1.013 bar [°C]	26.70	at 14.5 psi [°F]	78.30
Density	at 1.013 bar, 15 °C [kg/m^3]	687.00	at 1 atm., 70 °F [lb/ft^3]	42.89
Vapour pressure	at 0 °C [bar]	0.37	at 32 °F [psi]	5.37
	at 20 °C [bar]	0.83	at 70 °F [psi]	12.04
Flammability range in air [% volume]		5.4 – 46.6		

Hydrogen fluoride HF

CAS: 7664-39-3
EC: 231-634-8
UN: 1052

Purity grade	Typical purity	Typical impurities [ppm]			
		H_2	SO_2	H_2SO_4	H_2SiF_6
HiQ® Hydrogen fluoride 3.5	≥99.95 %	≤200 ppm(w)	≤10 ppm(w)	≤300 ppm(w)	≤20 ppm(w)

Typical filling pressure: 15 °C: 0.9 bar(a)/70 °F: 0 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Highly corrosive. Liquefied gas with pungent odour. Forms white fumes in humid air. Highly corrosive under humid conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
H330 – Fatal if inhaled; **H310** – Fatal in contact with skin; **H300** – Fatal if swallowed; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods

ADR Class 8, CT1

DOT Class 8

CHEM FOOD MANUF METAL PETRO R&D SEMI

Source

Hydrogen fluoride is prepared industrially by direct reaction of sulfuric acid and fluorspar (CaF_2). It is most commonly used in its anhydrous form.

Applications

Hydrogen fluoride is used in hydrogen fluoride lasers (HF/DF – hydrogen fluoride/deuterium fluoride lasers). These are infrared chemical lasers that can deliver continuous output power in the megawatt range.

It also serves as a catalyst in alkylation, acylation and isomerisation reactions, and as a dehydrating agent in cyclisation reactions.

Hydrogen fluoride may be used as a fumigant. For such purpose it may require registration/authorisation to comply with local legal requirements on pesticides/biocides.

Hydrogen fluoride is furthermore used:

- to produce fluorine
- to process uranium isotopes
- as a fluorinating agent to produce a variety of organic and inorganic chemicals
- to manufacture low-ash-content analytical filter paper
- for pickling of electronic components
- for etching in the production of semiconductor integrated circuits
- for etching and polishing glass
- to prepare fluoridised compounds
- for polymerisation and hydrolytic reactions
- for manufacturing of aluminium fluoride and synthetic cryolite (sodium alumina fluoride Na_3AlF_6).

Physical data

Molecular weight		20.006		
Boiling point	at 1.013 bar [°C]	19.52	at 14.5 psi [°F]	67.16
Density	at 1.013 bar, 15 °C [kg/m³]	0.92	at 1 atm., 70 °F [lb/ft³]	0.053
Vapour pressure	at 0 °C [bar]	0.48	at 32 °F [psi]	6.97
	at 20 °C [bar]	1.04	at 70 °F [psi]	15.48
Flammability range in air [% volume]		Non combustible		

Hydrogen iodide HI

Hydroiodic acid

CAS: 10034-85-2
EC: 233-109-9
UN: 2197

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Hydrogen iodide 3.0	≥99.9 %	contact local team

Typical filling pressure: 15 °C: 6 bar(a)/ 70 °F: 88.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Highly corrosive. Liquefied colourless gas with pungent odour. Forms white fumes in humid air. Highly corrosive under humid conditions. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

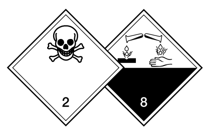
GHS-CLP

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H331** – Toxic if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM R&D SEMI

Source

The industrial preparation of hydrogen iodide involves the reaction of iodine with hydrazine, which also yields nitrogen gas.

Applications

Hydrogen iodide is used in semiconductor dry etching applications.

Hydrogen iodide is used in organic and inorganic synthesis as one of the primary sources of iodine, mostly as reducing agent.

Hydrogen iodide is mostly used for the production of hydroiodic acid, which is mainly used in chemical reactions because of its very strong acidity-induced reactivity.

Hydrogen iodide is also employed as a catalyst.

Physical data

Molecular weight		127.912		
Boiling point	at 1.013 bar [°C]	−35.4	at 14.5 psi [°F]	−31.72
Density	at 1.013 bar, 15 °C [kg/m^3]	5.48	at 1 atm., 70 °F [lb/ft^3]	0.342
Vapour pressure	at 0 °C [bar]	3.80	at 32 °F [psi]	55.16
	at 20 °C [bar]	6.91	at 70 °F [psi]	100.2
Flammability range in air [% volume]		Non combustible		

Hydrogen sulfide H_2S

CAS: 7783-06-4
EC: 231-977-3
UN: 1053

Purity grade	Typical purity	Typical impurities [ppm]	
		COS	methane
Hydrogen sulfide 1.8	≥98 %	≤4000	≤500

Typical filling pressure: 15 °C: 16 bar(a) 70 °F: 252 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

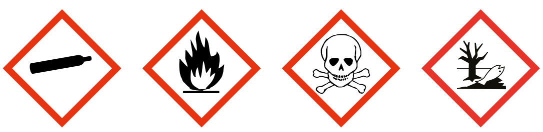
Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Extremely offensive odour, liquefied gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER



H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H330** – Fatal if inhaled; **H335** – May cause respiratory irritation; **H400** – Very toxic to aquatic life.

Transport of dangerous goods

ADR Class 2, 2TF

DOT Class 2.3

CHEM ENERGY MANUF METAL PETRO PHARMA R&D SEMI

Source

Hydrogen sulfide occurs as a by-product from many chemical processes. It is an off-gas in the production of viscose rayon, synthetic rubber, various petroleum products and dyes, as well as leather processing.

Hydrogen sulfide can also be manufactured by treatment of many metallic sulfides with a mineral acid such as hydrochloric or sulfuric acid.

Applications

Small quantities of hydrogen sulfide are used as a dopant for indium phosphide and gallium arsenide semiconductors, and as a precursor for the growth of zinc sulfide semiconductors.

Hydrogen sulfide is used for metal separation, removal of metallic impurities, and for preparation of metallic sulfides. In hot wire galvanising it is used in conjunction with natural gas to speed up the galvanising process.

Hydrogen sulfide is used to regenerate certain types of catalysts used in the petrochemical industry.

Hydrogen sulfide is used in calibration mixtures for the petrochemical industry.

Hydrogen sulfide is used in mixtures for emission control applications.

Hydrogen sulfide is used as an analytical reagent in chemical analysis.

Hydrogen sulfide is the main source for production of elemental sulfur.

Hydrogen sulfide is also employed for the production of additives in high-pressure lubricants and cutting oils.

Hydrogen sulfide is used in the chemical industry for production of sulfurated compounds, as mercaptans, sulfides, etc.

Hydrogen sulfide is also used as a solvent and as an odorant in town gas.

Hydrogen sulfide is used in the separation of heavy water from normal water in nuclear power stations.

Hydrogen sulfide is used for surface treatment of metals.

Physical data

Molecular weight		34.082		
Boiling point	at 1.013 bar [°C]	−60.35	at 14.5 psi [°F]	−76.61
Density	at 1.013 bar, 15 °C [kg/m^3]	1.454	at 1 atm., 70 °F [lb/ft^3]	0.089
Vapour pressure	at 0 °C [bar]	10.64	at 32 °F [psi]	154.40
	at 20 °C [bar]	18.40	at 70 °F [psi]	274.52
Flammability range in air [% volume]		3.9 – 45.5		

Krypton Kr

CAS: 7439-90-9
EC: 231-098-5
UN: 1056 (Compressed)
UN: 1970 (Refrigerated liquid)

Purity grade	Typical purity	Typical impurities [ppm]								
		H_2O	O_2	C_nH_m	$CO + CO_2$	H_2	N_2	Ar	CF_4	Xe
HiQ® Krypton 3.0 Window	≥99.9 %	≤10	≤60	≤30	-	-	-	-	-	-
HiQ® Krypton 4.0	≥99.99 %	≤5	≤10	≤5	-	-	≤30	-	-	-
HiQ® Krypton 5.0	≥99.999 %	≤2	≤0.5	≤0.5	≤1	≤1	≤2	≤1	≤1	≤1

Typical filling pressure: 15 °C: 130 bar(a) 70 °F: 1,900 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: **WARNING**

H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; **Refrigerated Gas → H281 –** Contains refrigerated gas; may cause cryogenic burns or injury; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 1A (Compressed)
3A (Refrigerated liquid)

DOT Class 2.2

CONSTR MANUF MEDICAL OEM R&D SEMI

Source

Krypton is obtained from air separation plants. In view of its very low natural concentration in air, it is only economically viable to recover krypton from larger plants. In these cases a stream containing a mixture of crude krypton and xenon is extracted from the plant and processed in a separate purification and distillation system.

Applications

Krypton is used in various research programmes.

Krypton is used for certain ion lasers and in mixtures with halides and helium or neon for excimer laser applications.

Krypton is used in incandescent lamps, mixed with nitrogen and argon or nitrogen, argon and xenon. Krypton is also used in mixtures with argon as a filling gas for fluorescent tubes.

Krypton is used as a filling gas for various halogen lamps, such as those used in cars, on airfields and in low-voltage display lamps.

In laboratories krypton is used for calibration standards for mass spectrometry and specific area measurements in adsorption applications.

In neurology krypton is used to obtain brain X-ray pictures.

Krypton is used as a triggering agent in discharge type electronic tubes (e.g. TFT screens; TFT LCD = Thin-Film Transistor Liquid Crystal Display).

Krypton is also used as an insulation gas in windows to reduce noise and heat transfer.

Physical data

Molecular weight		83.80		
Boiling point	at 1.013 bar [°C]	−153.35	at 14.5 psi [°F]	−244.01
Density	at 1.013 bar, 15 °C [kg/m³]	3.552	at 1 atm., 70 °F [lb/ft³]	0.217
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Methane CH_4

CAS: 74-82-8
EC: 200-812-7
UN: 1971 (Compressed)
UN: 1972 (Refrigerated liquid)
R-50

Purity grade	Typical purity	Typical impurities [ppm]				
		O_2	N_2	H_2	Other C_nH_m	H_2O
Methane 2.5	≥99.5 %	≤100	≤600	≤500	≤3,000	-
HiQ® Methane 3.5	≥99.95 %	≤30	≤200	≤20	≤300	-
HiQ® Methane 4.5	≥99.995 %	≤5	≤20	≤5	≤20	≤5
HiQ® Methane 5.5	≥99.9995 %	≤0.5	≤4	≤0.1	≤1	≤2

Typical filling pressure: 15 °C: 200 bar(a) 70 °F: 2,400 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Colourless and odourless gas. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER


H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H220 – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 1F (Compressed)
3F (Refrigerated liquid)

DOT Class 2.1

AUTO CHEM CONSTR ENERGY FOOD MANUF METAL OEM PETRO PHARMA R&D

Source

Methane is the principal constituent of natural gas (typically natural gas is 87% methane). It is therefore commonly produced by purifying natural gas.

Pure methane may also be obtained from the cracking of petroleum fractions in petrochemical refineries.

Applications

Methane is used as a heating fuel for domestic purposes and above all for industrial heating:

- in the steel industry, with open hearth furnaces, in the presence of fuel oil, and in reheating furnaces for semi-products prior to rolling or forging, oxycutting of metal, for heat treatment of nonferrous metals, and supply to infrared heating elements used for surface treatment
- in thermal power plants
- in glass making, annealing kilns for pharmaceutical ampoules, ceramic kilns
- in the textile industry
- in the chemical industry, petrochemical furnaces, heating of tanks containing resins for paints, vulcanisation of plastics
- in food and farm industries, coffee roasting ovens, malt drying in breweries, dehydration of plant fodder, powdered milk production
- in cement plants
- in paper mills

Methane was employed in gas batteries used by the Apollo space missions.

When mixed with argon or xenon, methane is used as a gas filling for proportional counters and other types of radiation detectors.

As natural gas it is also used as a fuel for vehicles.

In the chemical field, methane serves as a raw material for the production of methanol, synthetic ammonia, acetylene, carbon black, carbon disulfide, hydrocyanic acid, methyl chloride, methylene chloride, carbon tetrachloride and chloroform.

In the steel industry, natural gas is used for direct reduction of powdered minerals, and to produce hard metal.

Methane finds extensive use in various mixtures for quality control laboratories in the petrochemical and fuel gas industries.

Methane:

- is used as a fuel gas in flame photometers (high-purity).
- is used in gas cooled nuclear reactors. The methane is used to dope the carbon dioxide coolant in order to prevent erosion of the carbon control rods in the nuclear core.
- is used for efficiency testing of gas burners and engines.
- is also used in synthetic town gas mixtures.
- Liquid methane is used as a rocket fuel.

Methane mixtures are commonly used for calibrations in the automotive industry and in the environmental field.

Methane mixed with argon is used as make-up gas in electro-chemical detectors (EC detectors).

Note:

Methane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		16.043		
Boiling point	at 1.013 bar [°C]	−161.49	at 14.5 psi [°F]	−258.66
Density	at 1.013 bar, 15 °C [kg/m³]	0.680	at 1 atm., 70 °F [lb/ft³]	0.042
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		4.4 – 15.0		

Methyl bromide CH_3Br

Bromomethane

CAS: 74-83-9
EC: 200-813-2
UN: 1062

Purity grade	Typical purity	Typical impurities [ppm]		
		H_2O	Methanol	Acid as HBr
Methyl bromide 2.5	≥99.5 %	≤150 %(w)	≤150 %(w)	≤100 %(w)

Typical filling pressure: 15 °C: 1.6 bar(a)/70 °F: 13 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless liquefied gas, odourless in small concentrations. Has a chloroform type odour at high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H221** – Flammable gas; **H341** – Suspected of causing genetic defects; **H330** – Fatal if inhaled; **H301** – Toxic if swallowed; **H373** – May cause damage to CNS and muscle through prolonged or repeated exposure; **H319** – Causes serious eye irritation; **H335** – May cause respiratory irritation; **H315** – Causes skin irritation; **H400** – Very toxic to aquatic life; **H420** – Harms public health and the environment by destroying ozone in the upper atmosphere.

Transport of dangerous goods

ADR Class 2, 2TC

DOT Class 2.3

CHEM FOOD MANUF PETRO PHARMA R&D

Source

Commercial and laboratory methods of manufacturing Methyl bromide are generally similar and are based primarily on the reaction of hydrobromic acid (HBr) with methanol.

Other methods involve the treatment of bromine with a reducing agent, such as sulfur dioxide or phosphorus, in the presence of water.

More recently proposed processes involve the reaction of hydrogen bromide with excess methyl chloride.

Applications

Methyl bromide is used as a methylation agent in organic synthesis and also as a low-boiling solvent.

Methyl bromide is still widely used in fumigation of soils, seeds, flowers and fresh vegetables/fruits as well as for products manufactured from natural materials (e.g. wood, sisal).

Methyl bromide is already banned in many geographies for use in agriculture according to the phase-out process agreed under the Montreal Protocol.

Critical-use exemptions are listed for fumigation, quarantine and pre-shipment, as well as for emergency uses. To get a specific authorisation, a local registration may be required.

Note:

Methyl bromide is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer.

Physical data

Molecular weight		94.939		
Boiling point	at 1.013 bar [°C]	3.56	at 14.5 psi [°F]	38.43
Density	at 1.013 bar, 15 °C [kg/m^3]	4.106	at 1 atm., 70 °F [lb/ft^3]	0.251
Vapour pressure	at 0 °C [bar]	0.88	at 32 °F [psi]	12.76
	at 20 °C [bar]	1.84	at 70 °F [psi]	27.76
Flammability range in air [% volume]		8.6 – 20.0		

Methyl chloride CH_3Cl

Chloromethane

CAS: 74-87-3
EC: 200-817-4
UN: 1063
R-40

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Methyl chloride 2.8	≥99.8 %	contact local team

Typical filling pressure: 15 °C: 4.3 bar(a)/70 °F: 59 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, odourless gas with slight ether-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H351** – Suspected of causing cancer; **H373** – May cause damage to CNS, urogenital tract and liver through prolonged or repeated inhalation; **H361** – Suspected of damaging fertility or the unborn child.

ADR Class 2, 2F

DOT Class 2.1

CHEM MANUF MEDICAL METAL PETRO PHARMA R&D SEMI

Source

Methyl chloride is manufactured in commercial quantities by two principle processes:

- chlorination of methane
- reaction between hydrogen chloride and methanol.

Several variants of both processes are used. The methanol-hydrogen chloride reaction yields methyl chloride as the sole product. Chlorination of methane yields other chlorohydrocarbons in substantial amounts. Because the co-products, e.g. methylene chloride, chloroform, and carbon tetrachloride, are as commercially important as methyl chloride, methane chlorination can be regarded as a multiple-product process rather than one with several by-products. Hydrogen chloride is often the determining factor in choosing a route to produce methyl chloride.

Applications

Methyl chloride is used as:

- a catalyst solvent in butyl rubber production
- a reagent in silicone production
- in organic synthesis
- in the manufacturing of tetramethyl lead
- a solvent
- a starting material in the manufacturing of such chemicals as methyl mercaptan, methylene chloride, chloroform, carbon tetrachloride, various bromochloromethanes and chlorofluoromethanes
- in therapeutic treatment of local anaesthesia
- a solvent or extraction agent for heat sensitive products
- an aerosol propellant
- tool hardening and salt bath rectification.

Methyl chloride is an important chemical intermediate in the production of silicone polymers.

Methyl chloride is used in the production of quaternary ammonium compounds for use as anti-static agents in fabric softeners. It is also used for the manufacturing of methyl cellulose and in the production of Grignard reagents for the synthesis of pharmaceutical compounds. It also used in the preparation of fragrances, perfumes and herbicides.

Methyl chloride is used for side wall passivation in plasma etching to give anisotropic etching under plasma conditions: similar to reactive ion etching, but without the damage.

Methyl chloride is used to extract grease, wax, essential oils and resins during the production of textile and carpet materials.

Physical data

Molecular weight		50.487		
Boiling point	at 1.013 bar [°C]	−24.22	at 14.5 psi [°F]	−11.58
Density	at 1.013 bar, 15 °C [kg/m^3]	2.173	at 1 atm., 70 °F [lb/ft^3]	0.133
Vapour pressure	at 0 °C [bar]	2.59	at 32 °F [psi]	37.59
	at 20 °C [bar]	4.95	at 70 °F [psi]	74.28
Flammability range in air [% volume]		7.6 – 19.0		

Methyl formate $C_2H_4O_2$

Methyl methanoate

CAS: 107-31-3
EC: 203-481-7
UN: 1243
R-611

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
Methyl formate	≥97 %	≤500 ppm(w)

Typical filling pressure: 15 °C: 0.40 bar(a)/70 °F: 5.80 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics
Flammable. Colourless liquid with an agreeable odour. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
H224 - Extremely flammable liquid and vapour; H302+H332 - Harmful if swallowed or if inhaled; H319 - Causes serious eye irritation; H335 - May cause respiratory irritation.

Transport of dangerous goods

ADR Class 3, F1

DOT Class 3

CHEM CONSTR FOOD MANUF PETRO PHARMA

Source

Industrial methyl formate is usually produced by the combination of methanol and carbon monoxide (carbonylation) in the presence of a strong base, such as sodium methoxide.

Applications

Methyl formate is used primarily to manufacture formamide,formic acid and dimethylformamide. Because of its high vapour pressure, it is used for quick-drying finishes. It is also used as an insecticide and to manufacture certain pharmaceuticals. It is also used as a blowing agent for foam insulation, and as a replacement for CFCs, HCFCs or HFCs, with zero ODP and <25 GWP.

Physical data

Molecular weight		60.05		
Boiling point	at 1.013 bar [°C]	32	at 14.5 psi [°F]	89.6
Density	at 1.013 bar, 20 °C [kg/m^3]	0.98	at 1 atm., 70 °F [lb/ft^3]	0.0612
Vapour pressure	at 0 °C [bar]	0.21	at 32 °F [psi]	–
	at 20 °C [bar]	0.64	at 70 °F [psi]	9.86
Flammability range in air [% volume]		5.0 – 23.0		

Methyl mercaptan CH_3SH

Methanethiol

CAS: 74-93-1
EC: 200-822-1
UN: 1064

Purity grade	Typical purity	Typical impurities [ppm]
		Other S-comp.
HiQ® Methyl mercaptan 2.5	≥99.5 %	≤5,000

Typical filling pressure: 15 °C: 1.4 bar(a) 70 °F: 15 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

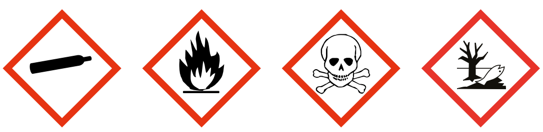
Flammable. Colourless, liquefied, gas with strong repugnant odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER



H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H331 – Toxic if inhaled; H410 – Very toxic to aquatic life with long lasting effects.

Transport of dangerous goods

ADR Class 2, 2TF

DOT Class 2.3

CHEM FOOD MANUF PETRO PHARMA R&D

Source

Methyl mercaptan is manufactured by reaction between hydrogen sulfide and methanol. The reaction is usually carried out over solid acidic catalysts at elevated temperatures.

Applications

Methyl mercaptan has been used in organic synthesis. It is also employed as an intermediate for jet fuels, fungicides and methionine, an essential amino acid allowed in some geographies as a nutrition supplement for animals.

Methyl mercaptan is employed as an additive to improve the quality of elastomers.

Methyl mercaptan is also used as an odorant in a variety of odourless gases to allow easy leak detection.

Methyl mercaptan is used as starting material in the manufacture of other chemicals such as petroleum chemical products.

Physical data

Molecular weight		48.109		
Boiling point	at 1.013 bar [°C]	5.96	at 14.5 psi [°F]	42.75
Density	at 1.013 bar, 15 °C [kg/m^3]	2.084	at 1 atm., 70 °F [lb/ft^3]	0.127
Vapour pressure	at 0 °C [bar]	0.78	at 32 °F [psi]	11.29
	at 20 °C [bar]	1.70	at 70 °F [psi]	25.67
Flammability range in air [% volume]		4.1 – 21.0		

Methyl vinyl ether C_3H_6O

Methoxyethene, Vinyl methyl ether

CAS: 107-25-5
EC: 203-475-4
UN: 1087

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
HiQ® Methyl vinyl ether 2.5	≥99.5 %	≤1,000

Typical filling pressure: 15 °C: 1.5 bar(a) 70 °F: 11.6 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Liquefied and colourless gas with a sweetish odour. Poor warning properties at low concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: **DANGER**


H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H231** – May react explosively even in absence of air at elevated pressure and/or temperature.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM MANUF PETRO R&D

Source

Methyl vinyl ether is obtained commercially by a vinylation reaction, that is treating ethyne (acetylene) with methanol in the presence of potassium hydroxide.

It is also prepared by converting acetaldehyde into dimethoxyethane, and subjecting the acetal to pyrolysis.

Applications

Methyl vinyl ether is used as an intermediate in organic synthesis.

Methyl vinyl ether is used to prepare homopolymers and copolymers like PFEs (perfluoroelastomers) or mixtures of MVE and maleic acid.

Methyl vinyl ether is used as a plasticiser for nitrocellulose and other plastics.

Physical data

Molecular weight		58.074		
Boiling point	at 1.013 bar [°C]	5.5	at 14.5 psi [°F]	41.92
Density	at 1.013 bar, 15 °C [kg/m³]	2.537	at 1 atm., 70 °F [lb/ft³]	0.155
Vapour pressure	at 0 °C [bar]	0.81	at 32 °F [psi]	11.70
	at 20 °C [bar]	1.74	at 70 °F [psi]	26.27
Flammability range in air [% volume]		2.2 – 28.2		

Methylamine $(CH_3)NH_2$

Monomethylamine, Aminomethane

CAS: 74-89-5
EC: 200-820-0
UN: 1061
R-630

Purity grade	Typical purity	Typical impurities [ppm]
		Other amines
Methylamine 2.0	≥99 %	≤1%

Typical filling pressure: 15 °C: 2.5 bar(a)/ 70 °F: 29 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied colourless gas with ammonia/fish-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas; **H332 –** Harmful if inhaled; **H335 –** May cause respiratory irritation; **H315 –** Causes skin irritation; **H318 –** Causes serious eye damage.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM FOOD MANUF PETRO PHARMA R&D

Source

Methylamine is produced industrially either by a reaction of methanol and ammonia in the presence of a catalyst or by a reaction between a carbonyl compound and ammonia. Dimethylamine and trimethylamine are also formed in the same reaction. The three products are separated by distillation.

Applications

Methylamine is an intermediate in the synthesis of pharmaceuticals (e.g. ephedrine or theophylline) and pesticides (carbaryl, metam sodium, carbofuran).

Methyl amine is also employed to produce surfactants and photographic developers.

Liquid methylamine can be used either as a solvent or in generating the solvents N-methylformamide or N-methylpyrrolidone.

Physical data

Molecular weight		31.057		
Boiling point	at 1.013 bar [°C]	−6.33	at 14.5 psi [°F]	20.63
Density	at 1.013 bar, 15 °C [kg/m³]	1.31	at 1 atm., 70 °F [lb/ft³]	0.082
Vapour pressure	at 0 °C [bar]	1.34	at 32 °F [psi]	19.46
	at 20 °C [bar]	2.96	at 70 °F [psi]	44.63
Flammability range in air [% volume]		4.9 – 20.7		

Neon Ne

CAS: 7440-01-9
EC: 231-110-9
UN: 1065 (Compressed)
UN: 1913 (Refrigerated liquid)
R-720

Purity grade	Typical purity	Typical impurities [ppm]				
		H_2O	O_2	C_nH_m	N_2	He
HiQ® Neon 4.5	≥99.995 %	≤3	≤2	≤0.2	≤5	≤20
HiQ® Neon 5.0	≥99.999 %	≤2	≤1	≤0.1	≤2	≤5

Typical filling pressure: 15 °C: 200 bar(a)/ 70 °F: 2,000 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Asphyxiant in high concentrations. Gas density is lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

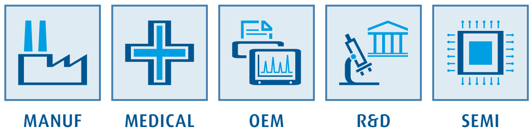
H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; **Refrigerated Gas → H281 –** Contains refrigerated gas; may cause cryogenic burns or injury; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 1A (Compressed)
3A (Refrigerated liquid)

DOT Class 2.2



Source

Neon is obtained from air separation plants. In view of its very low natural concentration in air, it is only economically viable to recover neon from larger air separation plants. In these cases small quantities of neon are recovered by splitting a crude neon stream from the plant and processing this in a separate purification and distillation system.

Applications

Neon is used as a filling gas in:
- → spark chamber particle detectors, in mixtures with helium and other particle detectors
- → Geiger tubes and other detectors
- → fluorescent lamps
- → sodium discharge lamps
- → digital display tubes (Dixie tubes)
- → stroboscope lights
- → signs, in mixtures with argon (hence the term Neon Lights)
- → low-consumption glow lamps (night lights)
- → filament lamps
- → telephone line surge arrestors

Neon is also used as either a buffer gas or the active medium in various types of gas lasers such as helium/neon, excimer and copper vapour lasers.

Neon is used as a carrier gas in chromatography for special applications.

Neon-oxygen breathing mixtures are used in diving, with the advantage of not causing vocal deformation.

Liquid neon is employed in the following applications:
- → liquid hydrogen replacement studies at about 30 K to satisfy safety considerations
- → cryo-sorption and cryo-pumping
- → nuclear particle detection in bubble chambers
- → lung diffusion gas

Neon is used in plasma TV screens.

Physical data

Molecular weight		20.18		
Boiling point	at 1.013 bar [°C]	−246.06	at 14.5 psi [°F]	−410.89
Density	at 1.013 bar, 15 °C [kg/m^3]	0.853	at 1 atm., 70 °F [lb/ft^3]	0.052
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Nitric oxide NO

Nitrogen monoxide

CAS: 10102-43-9
EC: 233-271-0
UN: 1660

Purity grade	Typical purity	Typical impurities [ppm]
HiQ® Nitric oxide 2.5	≥99.5 %	contact local team

Typical filling pressure: 15 °C: 30 bar(a)/ 70 °F: 500 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

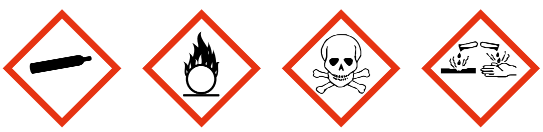
Colourless gas with slight odour. Gas density is slightly heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

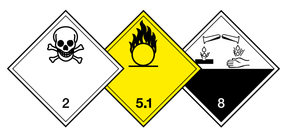
Signal word: DANGER



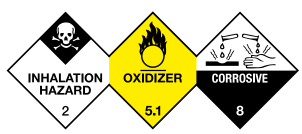
H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidiser; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 1TOC



DOT Class 2.3

AUTO CHEM ENERGY MEDICAL OEM PETRO R&D SEMI

Source

Nitric oxide is industrially produced by catalytic burning of ammonia.

Applications

Nitric oxide is used as a polymerisation inhibitor.

Nitric oxide is used in the bleaching of rayon fabrics.

Nitric oxide is used for oxidation of semiconductors in the electronics industry.

Nitric oxide is used
- → for chemical synthesis
- → in the preparation of metal nitryl carbonyls.

Nitric oxide gas mixtures with concentrations down to a ppb level are widely used to test and calibrate pollution and emission control analysers.

Nitric oxide gas mixtures are used therapeutically in neonatal, paediatric and adult medical therapies.

Nitric oxide may be classified as a medical gas in some geographies and managed according to the relevant regulations.

Physical data

Molecular weight		30.006		
Boiling point	at 1.013 bar [°C]	−151.77	at 14.5 psi [°F]	−241.17
Density	at 1.013 bar, 15 °C [kg/m³]	1.27	at 1 atm., 70 °F [lb/ft³]	0.078
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Nitrogen N_2

CAS: 7727-37-9
EC: 231-783-9
UN: 1066 (Compressed)
UN: 1977 (Refrigerated liquid)
R-728

Legend: N/D = Not Detectable

Purity grade	Purity	H_2O	O_2	C_nH_m	CO	CO_2	H_2	Ar	NO_x	SO_2	NO	Odour	Halocarbons
		Impurities [ppm]											
HiQ® Nitrogen 4.6	≥99.996 %	≤5	≤5	-	-	-	-	-	-	-	-	-	-
HiQ® Nitrogen 5.0	≥99.999 %	≤3	≤2	≤0.5	-	-	-	-	-	-	-	-	-
HiQ® Nitrogen 5.0 Zero	≥99.999 %	≤3	≤2	≤0.2	≤1	≤1	-	-	-	-	-	-	-
HiQ® Nitrogen 5.5 ECD	≥99.9995 %	≤1	≤1	≤0.1	≤0.5	≤0.5	-	-	-	-	-	-	≤1 ppb
HiQ® Nitrogen 5.5 CEM Zero	≥99.9995 %	≤1	≤0.5	≤0.1	≤0.5	≤1	-	-	≤0.1	≤0.1	-	-	-
HiQ® Nitrogen 6.0	≥99.9999 %	≤0.5	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	-	-	-	-	-	-
HiQ® Nitrogen 7.0	≥99.99999 %	≤50 ppb	≤30 ppb	≤30 ppb	≤30 ppb	≤30 ppb	≤30 ppb	-	-	-	-	-	≤1 ppb
HiQ® Nitrogen Euro 6 Raw	≥99.999 %	≤3	≤2	≤0.5	≤1	≤1	-	-	-	-	≤0.1	-	-
HiQ® Nitrogen Euro 6 Dilute	≥99.9999 %	≤0.5	≤0.5	≤0.05	≤0.1	≤0.1	-	-	-	-	≤0.02	-	-
VERISEQ® Process Nitrogen (pharmaceutical grade)	≥99.5 %	≤5	≤5	-	≤5	≤300	-	≤0.5 %	-	-	-	N/D	-
VERISEQ® Research Nitrogen (pharmaceutical grade)	≥99.999 %	≤3	≤3	≤1	≤5	≤300	-	≤0.5 %	-	-	-	N/D	-

Typical filling pressure: 15 °C: 200 bar(a)/70 °F: 2,640 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				Cryogenic liquid

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•	Cryogenic liquid	Consult local team

Characteristics

Colourless and odourless gas. Asphyxiant in high concentrations. Gas density is slightly lighter than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

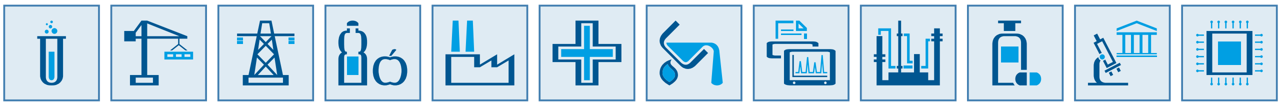
Proposed by the Industry
Signal word: WARNING

H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 1A (Compressed)
3A (Refrigerated liquid)

DOT Class 2.2



Source

Nitrogen is produced in large quantities at air separation plants which liquefy and subsequently distil air into nitrogen, oxygen and argon. If very high purity nitrogen is required the nitrogen produced may need to go through a secondary purification process. The lower range of nitrogen purities can also be produced with membrane techniques, and medium to high purities with pressure swing adsorption (PSA) techniques.

Applications

Nitrogen is used in large quantities in the chemical industry for blanketing, purging and pressure transfer of flammable chemicals.

High-purity nitrogen is used in large quantities by the semiconductor industry as a purge or carrier gas as well as for blanketing equipment such as furnaces when not in production.

Nitrogen is used as a purge gas.

Nitrogen is commonly used as carrier gas in gas chromatography.

Nitrogen is used as zero gas for analytical instruments. Nitrogen is commonly used as a balance gas in mixtures. Nitrogen is used in the electronic industry for inerting of epitaxial reactors.

Nitrogen is used in mixtures with carbon dioxide for modified atmosphere packaging (MAP) of food stuffs.

Nitrogen is used extensively, either pure or, more commonly, in a mixture with a reducing gas such as hydrogen or natural gas, to provide an oxygen free atmosphere during heat treatment of various metals.

Nitrogen is used in the Haber-Bosch process for production of ammonia.

Nitrogen is used as a fire extinguishing gas in mines.

Nitrogen is used to fill tires to reduce wear and limit the risks of blow-outs.

Liquid nitrogen is used in cold traps to improve the efficiency of vacuum pumps by condensing or solidifying residual gases in the vacuum.

Liquid nitrogen may be used for shrink fitting of close tolerance components.

Liquid nitrogen is used to freeze a wide variety of delicate food, such as hamburgers, strawberries, shrimps etc.

Liquid nitrogen may also be used for cryogenic grinding of plastics, rubbers and some other chemicals products.

Liquid nitrogen is used in the nuclear industry, for scientific research.

Liquid nitrogen is used to store biological materials like tissue, cells etc.

Liquid nitrogen is also used for cryo surgery.

Liquid nitrogen is used in the area of superconductivity.

Nitrogen is used in Liquid chromatography-mass spectrometry.

Physical data

Molecular weight		28.014		
Boiling point	at 1.013 bar [°C]	−195.8	at 14.5 psi [°F]	−320.42
Density	at 1.013 bar, 15 °C [kg/m^3]	1.185	at 1 atm., 70 °F [lb/ft^3]	0.072
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Nitrogen dioxide NO_2

CAS: 10102-44-0
EC: 233-272-6
UN: 1067

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
HiQ® Nitrogen dioxide 2.0	≥99 %	≤3,000

Typical filling pressure: 15 °C: 0.8 bar(a)/70 °F: 0 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

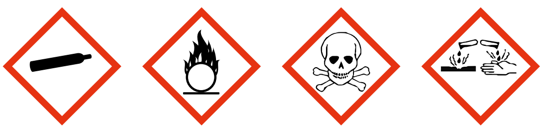
Characteristics

Reddish-brown liquefied gas with an asphyxiating odour. Corrosive in humid conditions. Heavy oxidising agent. Mixtures with organic materials can be explosive. Gas density is heavier than air.

Hazard classifications

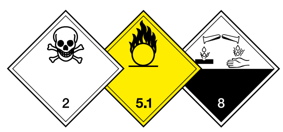
Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

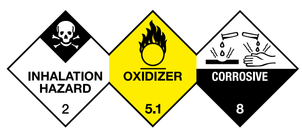


H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H270 –** May cause or intensify fire; oxidiser; **H330 –** Fatal if inhaled; **H314 –** Causes severe skin burns and eye damage; **EUH071 –** Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TOC



DOT Class 2.3

AUTO CHEM ENERGY OEM R&D

Source

Industrial production of nitrogen dioxide employs the Ostwald process (catalytic combustion of ammonia) and is the initial step in the production of nitric acid.

Other commercial processes for producing nitrogen dioxide are the oxidation of nitrosyl chloride yielding nitrogen dioxide and chlorine, and the treatment of sodium nitrite with nitric acid and oxidation of the liberated nitrogen monoxide to nitrogen dioxide.

High-purity nitrogen dioxide is obtained during the production of sodium nitrate from sodium chloride and nitric acid.

Applications

Nitrogen dioxide is employed in the production of calibration standards used in the inspection of combustion gases.

Nitrogen dioxide is used in calibration mixtures for the automotive industry.

Nitrogen dioxide is used in calibration mixtures for environmental monitoring in many process areas.

Nitrogen dioxide in the form of its dimer dinitrogen tetroxide is used as an oxidant in rocket fuels.

Nitrogen dioxide is employed in laboratories as an oxidising agent.

Nitrogen dioxide may also be used as a non-aqueous solvent in chemical extractions or as a reagent in chemical synthesis.

Physical data

Molecular weight		46.006		
Boiling point	at 1.013 bar [°C]	20.85	at 14.5 psi [°F]	69.55
Density	at 1.013 bar, 15 °C [kg/m^3]	1.98	at 1 atm., 70 °F [lb/ft^3]	0.121
Vapour pressure	at 0 °C [bar]	0.35	at 32 °F [psi]	5.09
	at 20 °C [bar]	0.96	at 70 °F [psi]	14.66
Flammability range in air [% volume]		Non combustible		

Nitrogen trifluoride NF_3

CAS: 7783-54-2
EC: 232-007-1
UN: 2451

Purity grade	Typical purity	Typical impurities [ppm]						
		H_2O	O_2	N_2	CO_2	CF_4	SF_6	N_2O
HiQ® Nitrogen trifluoride 4.0	≥99.99 %	≤1	≤5	≤50	≤15	≤50	≤10	≤10

Typical filling pressure: 15 °C: 19 bar(a) 70 °F: 261 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Colourless gas with characteristic mouldy odour. Highly oxidising at increased temperatures, can then ignite organic material. Gas density is heavier than air.

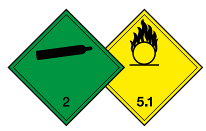
Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

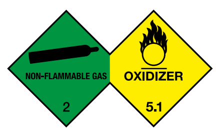
Proposed by the Industry
Signal word: DANGER

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H270 – May cause or intensify fire; oxidiser; H332 – Harmful if inhaled; H373 – May cause damage to the blood through prolonged or repeated inhalation.

Transport of dangerous goods



ADR Class 2, 20



DOT Class 2.2

CHEM | MANUF | METAL | R&D | SEMI

Source

Nitrogen trifluoride is prepared by direct catalytic fluorination of ammonia. It may also be obtained by electrolysis of molten ammonium bifluoride.

Known, but no longer used, is the direct combination of the elements nitrogen and fluorine using an electrical discharge at low temperatures.

Applications

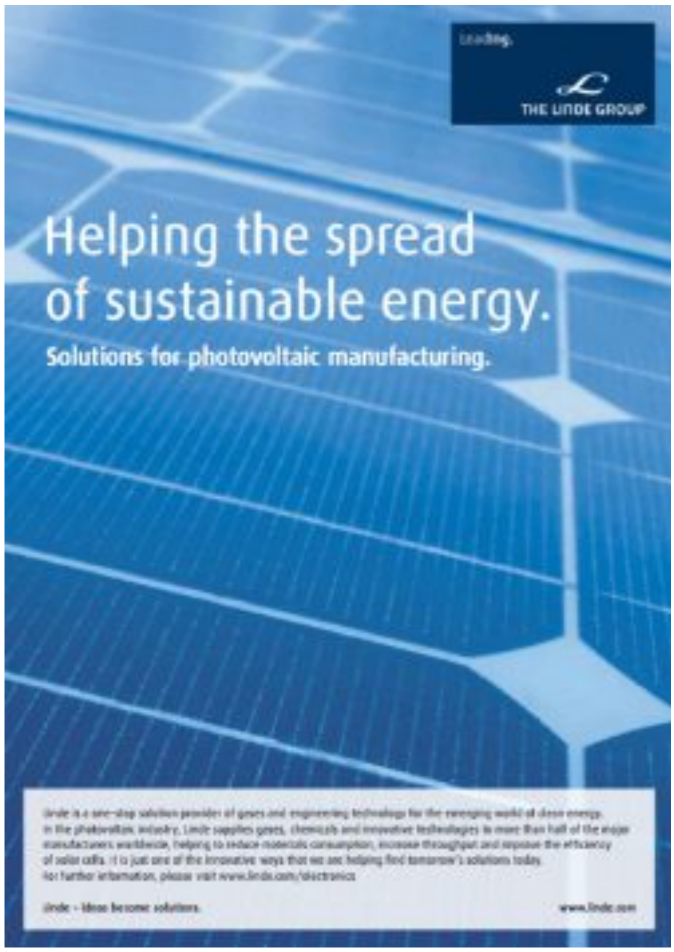
Nitrogen trifluoride is used as a high-speed, selective etchant in silicon processing. It is used to etch silicon, polysilicon, silicon nitride and silicon oxide as well as refractory metals and silicides.

Nitrogen trifluoride is used in cleaning chemical vapour reaction chambers for solar cell and LED screen production.

Nitrogen trifluoride has recently become of interest as a nitrogen source in generating nitride layers by chemical vapour deposition.

Nitrogen trifluoride is sometimes used as the fluorine source in HF/DF (see page XYZ) chemical lasers.

Nitrogen trifluoride is used as a fluorinating agent. Nitrogen trifluoride is also used for fibre treatment.



Physical data

Molecular weight		71.002		
Boiling point	at 1.013 bar [°C]	−129.05	at 14.5 psi [°F]	−200.29
Density	at 1.013 bar, 15 °C [kg/m³]	3.015	at 1 atm., 70 °F [lb/ft³]	0.184
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Nitrous oxide N_2O

CAS: 10024-97-2
EC: 233-032-0
UN: 1070
UN: 2201 (Refrigerated liquid)
R-744A

Purity grade	Typical purity	Typical impurities [ppm]						
		Air	H_2O	O_2	N_2	CO	CO_2	C_nH_m
Nitrous oxide 2.5	≥99.5 %	contact local team						
HiQ® Nitrous oxide 2.5 AAS	≥99.5 %	≤5,000 ppm	-	-	-	-	-	-
HiQ® Nitrous oxide 4.5	≥99.995 %	-	≤5	≤5	≤25	≤1	≤10	≤2
HiQ® Nitrous oxide 5.0	≥99.999 %	-	≤1	≤1	≤5	≤1	≤1	≤1

Typical filling pressure: 15 °C: 46 bar(a)/ 70 °F: 745 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

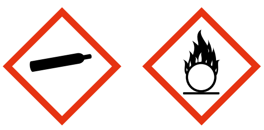
Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Oxidiser. Colourless and odourless gas. Gas density is heavier than air.

Hazard classifications

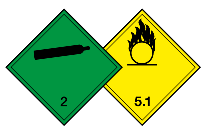
Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: DANGER

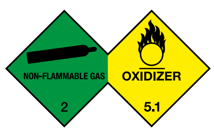


H-statements:
Compressed Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; H270 – May cause or intensify fire; oxidiser.

Transport of dangerous goods



ADR Class 2, 20
30 (Refrigerated liquid)



DOT Class 2.2

AUTO CHEM ENERGY FOOD MANUF MEDICAL OEM PHARMA R&D SEMI

Source

Nitrous oxide is obtained most commonly by the thermal decomposition of ammonium nitrate.

Nitrous oxide may also be obtained by controlled reduction of nitrites or nitrates, by the slow decomposition of hyponitrites, or by the thermal decomposition of hydroxylamine.

Applications

Nitrous oxide (also known as "laughing gas") is commonly used as a general anaesthetic in both medical and dental surgeries. To be effective as an anaesthetic, nitrous oxide must be inhaled in relatively high concentrations mixed with air or oxygen. Nitrous oxide may be classified as a medical gas in some geographies and managed according to the relevant regulations.

Nitrous oxide serves in industry as a leak detector for vacuum and pressurised enclosures, buried piping, etc.

Nitrous oxide is used as an oxygen source in the chemical vapour deposition of silicon oxynitride layers.

Nitrous oxide is used in calibration mixtures for environmental control.

The nitrous oxide-acetylene flame is employed in the laboratory for the analysis of refractory elements such as aluminium, vanadium, titanium and calcium oxides, by flame emission spectrometry. The use of this flame also permits determination of a certain number of trace metals by atomic absorption spectrometry.

Nitrous oxide is used as an oxidiser in some types of analytical instruments.

Nitrous oxide may be used as an aerosol/propellant in various fields:

- for whipped cream (because it improves the foaming characteristics of the cream), syrups, concentrates of coffee, chocolate and various flavours, sauces for grilled meats, vinaigrette, etc.
- in pharmaceutical sprays
- in cosmetics (perfumes, eau de cologne, hair spray, etc.)
- in household products, paints and varnishes, insecticides
- in aerosols for use at low temperatures, such as de-icers, engine starting boosters, etc.

Nitrous oxide is used as an oxygen enrichment medium for high-performance internal combustion engines (drag racing).

Nitrous oxide is used as oxidising component in the production of rocket fuels.

Nitrous oxide is used in the production of optical fibre.

Note:

Nitrous oxide is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		44.013		
Boiling point	at 1.013 bar [°C]	−88.48	at 14.5 psi [°F]	−127.24
Density	at 1.013 bar, 15 °C [kg/m^3]	1.873	at 1 atm., 70 °F [lb/ft^3]	0.114
Vapour pressure	at 0 °C [bar]	37.5	at 32 °F [psi]	543.9
	at 20 °C [bar]	58.5	at 70 °F [psi]	848.5
Flammability range in air [% volume]		Non combustible		

Octafluoropropane C_3F_8

Perfluoropropane, FC-218, R-218

CAS: 76-19-7
EC: 200-941-9
UN: 2424
R-218

Purity grade	Typical purity	Typical impurities [ppm]			
		H_2O	$N_2 + O_2$	Other halocarbons	Acidity
HiQ® Octafluoropropane 3.5	≥99.95 %	≤10	≤300	≤200	≤1 ppm(w)

Typical filling pressure: 15 °C: 6.7 bar(a)/ 70 °F: 100 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with an ethereal odour. Poor warning properties at low concentrations.Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: **WARNING**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CONSTR ENERGY MANUF MEDICAL R&D SEMI

Source

Perfluoroalkanes can be produced by a variety of routes. Indirect fluorination of hydrocarbons with cobalt (III) fluoride or silver (II) fluoride is carried out in a steel or nickel tube with stirring. The hydrocarbon vapours are passed at 150–450°C over the fluorinating agent, which is regenerated in a fluorine stream. This process is suitable for the production of perfluoroalkanes containing up to 20 carbon atoms.

Perfluoroalkanes can also be produced electrochemically by the Phillips Petroleum process or the electrochemical fluorination of organic compounds by the Simon's process.

Applications

Octafluoropropane is useful for high-voltage insulation.

Octafluoropropane is used in mixture with oxygen in semiconductor applications as an etching material for silicon dioxide layers. Oxides are selectively etched versus their metal substrates.

Octafluoropropane (R-218) is a component in refrigeration mixtures.

Octafluoropropane is also used for eye surgery.

It may be classified as a medical device in some geographies and managed according to the relevant regulations.

Note:

Octofluoropropane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		188.02		
Boiling point	at 1.013 bar [°C]	−36.75	at 14.5 psi [°F]	−34.13
Density	at 1.013 bar, 15 °C [kg/m³]	8.163	at 1 atm., 70 °F [lb/ft³]	0.498
Vapour pressure	at 0 °C [bar]	4.17	at 32 °F [psi]	60.46
	at 20 °C [bar]	7.69	at 70 °F [psi]	115.05
Flammability range in air [% volume]		Non combustible		

Oxygen O_2

CAS: 7782-44-7
EC: 231-956-9
UN: 1072 (Compressed)
UN: 1073 (Refrigerated liquid)
R-732

Purity grade	Purity	Impurities [ppm]						
		H_2O	C_nH_m	CO	CO_2	N_2	Ar	Odour
HiQ® Oxygen 3.5	≥99.95 %	≤5	-	-	-	-	-	-
HiQ® Oxygen 4.8	≥99.998 %	≤3	≤1	-	-	≤10	≤10	-
HiQ® Oxygen 5.0 Zero	≥99.999 %	≤3	≤0.2	≤1	≤1	≤5	≤5	-
HiQ® Oxygen 6.0	≥99.9999 %	≤0.5	≤0.1	≤0.1	≤0.1	≤0.5	≤1	-
VERISEQ® Process Oxygen (pharmaceutical grade)	≥99.5 %	≤67	-	≤5	≤300	-	-	N/D

Typical filling pressure: 15 °C: 200 bar(a)/ 70 °F: 2,640 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•	•				Cryogenic liquid

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•	Cryogenic liquid	Consult local team

Characteristics

Colourless and odourless gas. Many materials burn in oxygen that do not normally burn in air. Reduces the flash-point temperature and increases the combustion speed. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

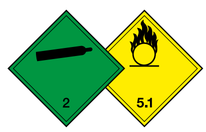
GHS-CLP

Signal word: DANGER

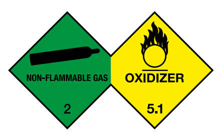
H-statements:

Compressed Gas → H280 – Contains gas under pressure; may explode if heated; **Refrigerated Gas → H281 –** Contains refrigerated gas; may cause cryogenic burns or injury; **H270 –** May cause or intensify fire; oxidiser.

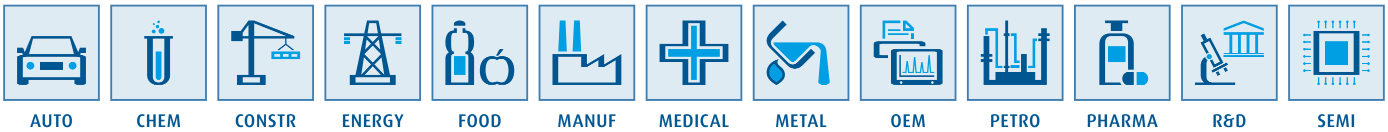
Transport of dangerous goods



ADR Class 2, 10 (Compressed)
30 (Refrigerated liquid)



DOT Class 2.2



Source

Oxygen is obtained on a commercial scale by the liquefaction and subsequent distillation of air. For very high purity oxygen it is normally necessary to take the product from an air separation plant through a secondary purification and distillation stage. Alternatively high-purity oxygen may be produced by the electrolysis of water. Lower purities of oxygen can also be produced with membrane technique.

Applications

Many oxidation reactions in the chemical industry use pure oxygen rather than air in order to benefit from higher reaction rates, easier product separation, higher yields, or smaller equipment size.

High-purity oxygen is used for the formation of silicon dioxide and metal oxide, as an etchant for photoresist, and in mixtures with halocarbons for etching silicon. Oxygen is also used in conjunction with hydrogen to fuel torches for welding, brazing, glass blowing and tube sealing for a variety of electronic components such as reed relay switches.

High-purity oxygen is used in conjunction with high-purity methane in Advanced Gas Cooled (AGR) nuclear reactors to maintain an appropriate carbon balance in the (CO_2) gas coolant in the nuclear core.

High-purity oxygen is used in the optical fibre production process.

Injecting oxygen into sewage treatment plants accelerates the decomposition of sewage.

Oxygen is used for chemical synthesis.

Oxygen is used as an oxidiser.

Oxygen is used to supplement or replace air in burners used in many different industries in order to obtain increased temperatures. Typical applications are found in the steel, non-ferrous, glass and concrete industries amongst many others.

Oxygen is used for flame sealing of glass ampoules for finished products for the pharmaceutical industry and the chemical industry.

In the food industry, oxygen is used in the transportation of live fish and seafoods.

Oxygen is used for enrichment of air during fermentation.

Mixed with other gases, oxygen serves in the production of breathable atmospheres (O_2 + CO_2: reanimation; O_2 + He or O_2 + N_2: underwater diving).

Oxygen is used in some cases for modified atmosphere packaging (MAP) of food stuffs. It is used either pure or in mixtures with carbon dioxide and/or nitrogen.

Liquid oxygen is used in liquid oxygen explosives, and as a comburent in space propulsion.

Oxygen is used in the medical field, as pure gas and in mixtures.

Oxygen is also used in calibration gas.

Oxygen is used in metal treating laser applications. Oxygen is used in cutting and welding.

Physical data

Molecular weight		31.999		
Boiling point	at 1.013 bar [°C]	−182.98	at 14.5 psi [°F]	−297.34
Density	at 1.013 bar, 15 °C [kg/m³]	1.354	at 1 atm., 70 °F [lb/ft³]	0.083
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Pentafluoroethane C_2HF_5

HFC-125, R-125

CAS: 354-33-6
EC: 206-557-8
UN: 3220
R-125

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
Pentafluoroethane	≥99.5 %	≤10 ppm(w)

Typical filling pressure: 15 °C: 10.2 bar(a)/70 °F: 180.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with a slight ethereal smell. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

H280 - Contains gas under pressure; may explode if heated.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CHEM CONSTR FOOD PETRO

Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. Many synthesis routes for pentafluoroethane use trichloroethylene and/or tetrachloroethylene (also known as perchloroethylene, PCE), which is reacted with HF, often in the presence of a catalyst.

Applications

Pentafluoroethane is commonly used as a refrigerant gas. It is a hydrofluorocarbon (HFC) and is given the ASHRAE number R-125. It is used as a component in many HFC refrigerant gas blends, including R404A, R410A, R407A,C and F and many R22 retrofit replacements.

Pentafluoroethane is also used in its pure form as a fire suppression agent.

Note:

Pentafluoroethane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		120.02		
Boiling point	at 1.013 bar [°C]	-68.5	at 14.5 psi [°F]	-91.3
Density	at 1.013 bar, 20 °C [kg/m^3]	5.83	at 1 atm., 70 °F [lb/ft^3]	0.3640
Vapour pressure	at 0 °C [bar]	6.7	at 32 °F [psi]	113.6
	at 20 °C [bar]	12.4	at 70 °F [psi]	180.4
Flammability range in air [% volume]		Not combustible		

1,1,1,3,3-Pentafluoropropane $C_3H_3F_5$

HFC-245fa, R-245fa

CAS: 460-73-1
EC: 419-170-6
UN: 3163
R-245fa

Purity grade	Typical purity	Typical impurities [ppm]
		H_20
1,1,1,3,3-Pentafluoropropane	≥99.8 %	≤20 ppm(w)

Typical filling pressure: 15 °C: 1.01 bar(a)/70 °F: 178.0 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquified gas with a slight smell. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: WARNING

H-statements:
H280 - Contains gas under pressure; may explode if heated.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CHEM CONSTR FOOD PETRO

Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for 1,1,1,3,3-pentafluoropropane involves reacting 1,1,1,3,3,3-hexafluoropropane (HFC-236fa) with a source of hydrogen.

Applications

1,1,1,3,3-pentafluoropropane (HFC-245fa) is used primarily for foam blowing applications. It is a non-ozone-depleting alternative to R141b.

Note:

1,1,1,3,3-pentafluoropropane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		134.05		
Boiling point	at 1.013 bar [°C]	15.3	at 14.5 psi [°F]	59.5
Density	at 1.013 bar, 20 °C [kg/m^3]	1.32	at 1 atm., 70 °F [lb/ft^3]	0.0824
Vapour pressure	at 0 °C [bar]	0.53	at 32 °F [psi]	7.7
	at 20 °C [bar]	12.27	at 70 °F [psi]	178.0
Flammability range in air [% volume]		Not combustible		

n-Pentane C_5H_{12}

Pentane

CAS: 109-66-0
EC: 203-692-4
UN: 1265
R-601

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
n-Pentane	≥95 %	≤100 ppm(w)

Typical filling pressure: 15 °C: 0.46 bar(a)/70 °F: 8.57 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable. Colourless, nearly odourless liquid. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

H-statements:

H224 - Extremely flammable liquid and vapour; **H304** - May be fatal if swallowed and enters airways; **H336** - May cause drowsiness or dizziness; **H411** - Toxic to aquatic life with long lasting effects; **EUH066** - Repeated exposure may cause skin dryness or cracking.

Transport of dangerous goods

ADR Class 3, F1

DOT Class 3

CHEM CONSTR FOOD MANUF PETRO

Source

n-Pentane is mainly produced/separated by fractional distillation in refineries.

Applications

Pentanes are some of the primary blowing agents used in the production of polystyrene foam and other foams. The pentanes are sold in pure form, and within blends. They have replaced fluorocarbon gases in many applications due to their zero ozone depletion and low global warming potential.

Physical data

Molecular weight		72.15		
Boiling point	at 1.013 bar [°C]	36.06	at 14.5 psi [°F]	96.9
Density	at 1.013 bar, 20 °C [kg/m^3]	0.62638	at 1 atm., 70 °F [lb/ft^3]	0.0391
Vapour pressure	at 0 °C [bar]	0.24	at 32 °F [psi]	4.7
	at 20 °C [bar]	0.59	at 70 °F [psi]	8.57
Flammability range in air [% volume]		1.4 – 8.0		

iso-Pentane C_5H_{12}

2-methylbutane

CAS: 78-78-4
EC: 201-142-8
UN: 1265
R-601a

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
iso-Pentane	≥95 %	≤100 ppm(w)

Typical filling pressure: 15 °C: 0.64 bar(a)/70 °F: 11.04 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable. Colourless liquid with a petrol-like odour. Vapour is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

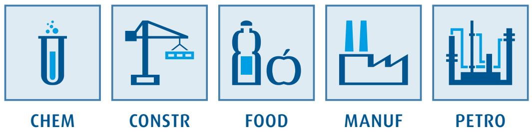
H-statements:

H224 - Extremely flammable liquid and vapour; **H304** - May be fatal if swallowed and enters airways; **H336** - May cause drowsiness or dizziness; **H411** - Toxic to aquatic life with long lasting effects; **EUH066** - Repeated exposure may cause skin dryness or cracking.

Transport of dangerous goods

ADR Class 3, F1

DOT Class 3



Source

iso-Pentane is mainly produced via catalytic isomerisation of n-Pentane.

Applications

Pentanes are some of the primary blowing agents used in the production of polystyrene foam and other foams. Often a mixture of n-Pentane, i-Pentane and increasingly cyclopentane is used. They have replaced fluorocarbon gases due to their zero ozone depletion and low global warming potential.

Physical data

Molecular weight		72.15		
Boiling point	at 1.013 bar [°C]	27.8	at 14.5 psi [°F]	82.04
Density	at 1.013 bar, 20 °C [kg/m^3]	0.62	at 1 atm., 70 °F [lb/ft^3]	0.0387
Vapour pressure	at 0 °C [bar]	0.35	at 32 °F [psi]	4.9
	at 20 °C [bar]	0.76	at 70 °F [psi]	11.04
Flammability range in air [% volume]		1.4 – 7.6		

Phosgene $COCl_2$

Carbonyl chloride, Dichloromethanal

CAS: 75-44-5
EC: 200-870-3
UN: 1076

Purity grade	Typical purity	Typical impurities [ppm]
		$HCl+Cl_2$
HiQ® Phosgene 2.0	≥99 %	≤10,000

Typical filling pressure: 15 °C: 1.3 bar(a)/70 °F: 9.3 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Corrosive. Colourless, liquefied gas with a damp hay-like odour. Decomposes in water to hydrogen chloride and carbon dioxide. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

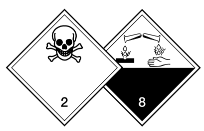
GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract; H400 – Very toxic to aquatic life.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM MANUF PETRO PHARMA R&D

Source

Phosgene is obtained commercially by passing carbon monoxide and chlorine over a catalytic bed of activated carbon. The produced phosgene is liquefied in a condenser and the residual product gases are carefully scrubbed for removal of remaining phosgene.

Applications

Phosgene is widely used in organic synthesis to prepare, e.g.:

- acyl halides as intermediates
- intermediate isocyanates (MDI and TDI) in the preparation of polyurethanes
- polycarbonate resins (thermoplastics)
- ethyl, isopropyl, diethylene glycol and n-butyl chloroformates
- dyes
- pharmaceuticals
- synthetic foams
- urea and substituted ureas
- carbodiimides

Phosgene is also used in the production of insecticides, herbicides and pesticides. For such use, phosgene may require registration/authorisation to comply with local legal requirements on biocides/pesticides.

Phosgene also serves in the bleaching of sand for the glass industry. It is a chlorinating agent.

Physical data

Molecular weight		98.916		
Boiling point	at 1.013 bar [°C]	7.56	at 14.5 psi [°F]	45.63
Density	at 1.013 bar, 15 °C [kg/m³]	4.308	at 1 atm., 70 °F [lb/ft³]	0.263
Vapour pressure	at 0 °C [bar]	0.75	at 32 °F [psi]	10.8
	at 20 °C [bar]	1.59	at 70 °F [psi]	24.0
Flammability range in air [% volume]		Non combustible		

Phosphine PH_3

Hydrogen phosphide

CAS: 7803-51-2
EC: 232-260-8
UN: 2199

Purity grade	Typical purity	Typical impurities [ppm]						
		O_2	N_2	CO	CO_2	C_nH_m	H_2O	AsH_3
HiQ® Phosphine 5.0	≥99.999 %	≤1	≤3	≤1	≤1	≤2	≤1	≤2

Typical filling pressure: 15 °C: 37 bar(a)/70 °F: 507.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Liquefied, colourless gas with an odour similar to rotten fish. Ignites spontaneously in air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H330** – Fatal if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract; **H400** – Very toxic to aquatic life.

Transport of dangerous goods

ADR Class 2, 2TF

DOT Class 2.3

CHEM FOOD MANUF R&D SEMI

Source

Phosphine may be prepared by a number of routes including hydrolysis of metal phosphides or direct combination of the elements under pressure.

Phosphine is industrially produced either by reaction of white phosphorous with sodium or potassium hydroxide at elevated temperature or acid-catalysed disproportioning of white phosphorus.

Higher purity phosphine may be generated by the reaction of potassium hydroxide with phosphonium iodide (PH4I).

Applications

Phosphine is used as a fumigant to kill insect infestation in grain silos. Phosphine may require registration/ authorisation for such usage to comply with local legal requirements on biocides/pesticides.

Phosphine is used as an n-type dopant in the epitaxial deposition and diffusion of silicon. It is also used for the epitaxial growth of InP and GaInAsP for the production of semiconductors.

Phosphine is used for charging of silica linings.

In the chemical industry, phosphine finds use in the preparation of flame-retarding compounds.

Phosphine-containing mixtures are used in halogen lamp production as bulb filling.

Physical data

Molecular weight		33.998		
Boiling point	at 1.013 bar [°C]	−87.74	at 14.5 psi [°F]	−125.91
Density	at 1.013 bar, 15 °C [kg/m^3]	1.449	at 1 atm., 70 °F [lb/ft^3]	0.089
Vapour pressure	at 0 °C [bar]	22.37	at 32 °F [psi]	324.4
	at 20 °C [bar]	35.16	at 70 °F [psi]	522.11
Flammability range in air [% volume]		1.6 – 98.0 Pyrophoric		

Propadiene C_3H_4

Allene, 1,2-Propadiene

CAS: 463-49-0
EC: 207-335-3
UN: 2200

Purity grade	Typical purity	Typical impurities [ppm]	
		Other C_nH_m	H_2O
HiQ® Propadiene 2.5	≥99.5 %	≤5,000	≤100

Typical filling pressure: 15 °C: 5.5 bar(a) / 70 °F: 80.0 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless, liquefied gas with slightly sweetish odour. Poor warning properties at low concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220 –** Extremely flammable gas; **H231 –** May react explosively even in absence of air ar elevated pressure and/or temperature.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO PHARMA R&D

Source

Propadiene occurs in jointly, +exists in equilibrium with methylacetylene as a side product, often an undesirable one, of cracking propane to produce propylene, an important feedstock in the chemical industry.

Propadiene is produced through the pyrolysis of isobutane at elevated temperature and controlled pressure.

Propadiene can also be obtained by debromination of 2,3-dibromopropene or dechlorination of 2,3-dichloropropene.

Applications

Propadiene is of interest in organic synthesis and is used in the manufacture of pharmaceutical intermediates and in the production of insecticides.

Propadiene is used as a component in calibration gases for the gas, oil and chemical industries.

Propadiene mixtures are used as cutting gas in the manufacturing industry.

Physical data

Molecular weight		40.065		
Boiling point	at 1.013 bar [°C]	–34.5	at 14.5 psi [°F]	–30.08
Density	at 1.013 bar, 15 °C [kg/m^3]	1.725	at 1 atm., 70 °F [lb/ft^3]	0.105
Vapour pressure	at 0 °C [bar]	3.55	at 32 °F [psi]	51.54
	at 20 °C [bar]	6.34	at 70 °F [psi]	94.72
Flammability range in air [% volume]		1.9 – 17.0		

Propane C_3H_8

R-290

CAS: 74-98-6
EC: 200-827-9
UN: 1978

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
Propane 1.5	≥95 %	-
Propane 2.5	≥99.5 %	≤5,000
HiQ® Propane 3.5	≥99.95 %	≤500

Typical filling pressure: 15 °C: 7.3 bar(a)/ 70 °F: 109 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless, liquefied gas. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**


H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

AUTO CHEM CONSTR ENERGY FOOD MANUF METAL OEM PETRO PHARMA R&D

Source
Propane is a constituent of crude petroleum and natural gas, from which it is obtained by refining and processing operations.

Applications
Propane is a main component in liquid petroleum gas (LPG).

Propane is of interest as a specialty gas mainly in mixtures used to calibrate process control analysers in the petrochemical industry.

Propane is also used in its pure form as the fuel gas in flame photometers.

Propane is used:
- → for heating of industrial premises and apartments
- → as fuel supply to hot air generators used in farming for drying harvests
- → for heating animal breeding areas
- → for cooking in hotels and restaurants
- → in portable heating units at work sites, markets, etc.
- → in the iron and steel industry: burners for heat treatment furnaces, radiation panels for surface treatment, metal oxycutting
- → in the chemical industry, e.g. burners for ceramic kilns, in paintwork finishing installations, incinerators in petrochemical furnaces
- → as a clean fuel for intra-plant vehicles, such as forklift trucks, where petrol fumes or soot would be considered unpleasant
- → extensively as a refrigerant in chemical, petroleum refining and gas processing operations
- → as a refrigerant in high/medium/low temperature applications for commercial and industrial refrigeration and A/C
- → in heat pumps, and mixed with iso-butane in high/medium temperature commercial and domestic refrigeration applications
- → in metallurgy to create controlled atmospheres. It is employed in gaseous cementation processes
- → as an aerosol propellant mixed with iso-butane.

Propane as a refrigerant has the ASHRAE number R-290.

It is also used in small proportions as a component in some hydrochlorofluorocarbon and hydrofluorocarbon (HCFC, HFC) refrigerant blends for industrial and commercial refrigeration and air conditioning applications in order to facilitate oil return in the system.

In the chemical industry, propane is used in the production of: ethylene, propylene, which is an intermediate product in the manufacture of isopropanol, propylene oxide, propylene glycol, acrolein, acrylic acid, acrylonitrile, isopropylbenzene, allyl chloride, epichlorohydrin and polypropylene.

Propane and its blends are used for efficiency testing of gas burners and engines.

Propane is used in mixtures for emission control in the automotive industry.

Propane is used as a component in calibration gases for the gas, oil and chemical industries.

Physical data

Molecular weight		44.097		
Boiling point	at 1.013 bar [°C]	−42.04	at 14.5 psi [°F]	−43.65
Density	at 1.013 bar, 15 °C [kg/m^3]	1.901	at 1 atm., 70 °F [lb/ft^3]	0.116
Vapour pressure	at 0 °C [bar]	4.76	at 32 °F [psi]	69.01
	at 20 °C [bar]	8.39	at 70 °F [psi]	125.24
Flammability range in air [% volume]		1.7 – 10.8		

Propylene C_3H_6

Propene

CAS: 115-07-1
EC: 204-062-1
UN: 1077
R-1270

Purity grade	Typical purity	Typical impurities [ppm]
		Other C_nH_m
Propylene 2.5	≥99.5 %	contact local team
HiQ® Propylene 2.8	≥99.8 %	≤1,000

Typical filling pressure: 15 °C: 9 bar(a)/ 70 °F: 136 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless, liquefied gas with a sweetish odour. Poor warning properties at low concentrations (stenchant often added). Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **DANGER**

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

AUTO CHEM CONSTR ENERGY MANUF PETRO PHARMA R&D

Source

Propylene is obtained during the refining of gasoline, and to a lesser extent by the splitting, cracking and reforming of hydrocarbon mixtures.

Propylene is a by-product of oil refining and natural gas processing. It may also be taken from naphtha cracking.

Propylene is separated by fractional distillation from hydrocarbon fractions. For higher product qualities, further distillation is required.

The shale gas industry opened up an alternative production path by dehydrogenating propane to yield Propylene.

Applications

Propylene is used in organic synthesis to produce, e.g. the following materials:

- acetone
- isopropanolacrylonitrile
- propylene oxide

Propylene in major quantities is polymerised to form polypropylene plastics.

It is used as a refrigerant in high/medium/low temperature applications including commercial refrigeration and air-conditioning. It has the ASHRAE number R-1270.

Propylene is used in mixtures for the calibration of process control instruments in the petrochemical/chemical industry.

Propylene is widely used as a chemical intermediate.

Propylene is used in emission calibration mixtures for the automotive industry.

Propylene is used in the efficiency testing of gas burners and engines.

Propylene is used as a component in calibration gases for the chemical industry.

Physical data

Molecular weight		42.081		
Boiling point	at 1.013 bar [°C]	−47.69	at 14.5 psi [°F]	−53.82
Density	at 1.013 bar, 15 °C [kg/m^3]	1.809	at 1 atm., 70 °F [lb/ft^3]	0.111
Vapour pressure	at 0 °C [bar]	5.88	at 32 °F [psi]	85.26
	at 20 °C [bar]	10.24	at 70 °F [psi]	152.86
Flammability range in air [% volume]		1.8 – 11.2		

Propyne C_3H_4

Allylene, Methylacetylene

CAS: 74-99-7
EC: 200-828-4
UN: 1060

Purity grade	Typical purity	Typical impurities [ppm]
Propyne	on request	contact local team

Typical filling pressure: 15 °C: 4.4 bar(a)/70 °F: 59.4 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Colourless, liquefied gas with a garlic like odour. Poor warning properties at low concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)
Proposed by the Industry
Signal word: DANGER

H-statements:
Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas; **H231** – May react explosively even in absence of air ar elevated pressure and/or temperature.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM PETRO PHARMA R&D

Source

Propyne can be produced by thermal or catalytic pyrolysis of propylene.

Cracking of hydrocarbons yields blends containing propyne and propadiene which are recovered by solvent extraction. From these enriched C3 fractions propyne is further enriched by low temperature fractional distillation.

Alternatively it is also extracted by selective hydrogenation. In cracked gas (for example, from steam cracking of hydrocarbons), propyne, together with propadiene, can be

recovered by solvent extraction and enriched by low temperature fractional distillation of C3 mixtures, or removed by selective hydrogenation.

Applications

Propyne is used in the chemical industry as a synthesis intermediate.

Propyne is used as a component in calibration gases for the gas, oil and chemical industries.

As an intermediate it is also used in the synthesis of vitamin E.

Propyne may be used together with liquid oxygen as a high-performing rocket fuel.

Propyne blends are used as a cutting and welding gas in the manufacturing industry.

Physical data

Molecular weight		40.065		
Boiling point	at 1.013 bar [°C]	−23.21	at 14.5 psi [°F]	−9.76
Density	at 1.013 bar, 15 °C [kg/m³]	1.728	at 1 atm., 70 °F [lb/ft³]	0.106
Vapour pressure	at 0 °C [bar]	2.55	at 32 °F [psi]	36,92
	at 20 °C [bar]	4.94	at 70 °F [psi]	74.09
Flammability range in air [% volume]		1.8 – 16.8		

Silane SiH_4

Silicon hydride, Monosilane

CAS: 7803-62-5
EC: 232-263-4
UN: 2203

Purity grade	Typical purity	Typical impurities [ppm]						
		SiH_3Cl	H_2O	O_2	N_2	$CO + CO_2$	C_nH_m	H_2
HiQ® Silane 4.0	≥99.99 % – Resistivity >300 Ω/cm	≤2	≤2	≤1	≤20	≤5	≤5	≤200
HiQ® Silane 5.0	≥99.999 % – Resistivity >2000 Ω/cm	≤0.5	≤1	≤1	≤3	≤1	≤0.5	≤50

Typical filling pressure: 15 °C: 50-100 bar(a)770 °F: 700 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless gas with repulsive odour. Forms white fumes at leakage. Mixtures with more than 3% silane ignites spontaneously in air. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: **DANGER**

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H220** – Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

MANUF R&D SEMI

Source

Silane is industrially produced through many differing reaction routes. A two-step process starts with reacting powdered silicon and hydrogen chloride at elevated temperature. The generated trichlorosilane in a subsequent reaction step catalytically forms silane by further heating.

High-purity silane used in the generation of semiconductor grade silicon is yielded in a complex redistribution reaction starting off with metallurgical grade silicon reacted with silicon tetrachloride and hydrogen.

Silane is also commercially produced by reduction of SiF4 with sodium hydride or reduction of SiCl4 with lithium aluminium hydride.

Another commercial synthesis involves reduction of silicon dioxide in a mixture of sodium chloride and aluminium chloride in the presence of aluminium and gaseous hydrogen at high pressure.
Silane in smaller volumes is produced by the reduction of silicon tetrachloride by metal hydrides such as lithium or calcium aluminium hydride.

Silane can also be produced by treatment of magnesium silicide with hydrochloric acid.

Applications

Silane is used in the production of specialty glasses to provide a reflective coating like in the automotive industry.

Silane is one of the basic materials in the silicon-based semiconductor industry. It is used as a source of silicon for growing polycrystalline and epitaxial (monocrystalline) silicon, silicon dioxide, silicon nitride and doping of gallium arsenide.

Silane is also used as a dopant in the production of compound semiconductor devices, for chemical vapour deposition of refractory metal silicides, and for deposition of amorphous silicon on photocopier drums.

Silane is also used in the production of photovoltaic cells.

Silane is used in the production process of optical fibres.
Silane is used as a reducing reagent in organic and organo-metallic chemistry.

Physical data

Molecular weight		32.117		
Boiling point	at 1.013 bar [°C]	−112.15	at 14.5 psi [°F]	−169.85
Density	at 1.013 bar, 15 °C [kg/m^3]	1.366	at 1 atm., 70 °F [lb/ft^3]	0.085
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		1.0 – 96.0 Pyrophoric		

Silicon tetrachloride $SiCl_4$

Tetrachlorosilane

CAS: 10026-04-7
EC: 233-054-0
UN: 1818

Purity grade	Typical purity	Typical impurities [ppm]					
		SiH_nCl_m	Al	B	C	Fe	P + As
HiQ® Silicon tetrachloride 3.5	≥99.95 % – Resistivity >100 Ω/cm	≤600 ppm	≤50 ppb	≤0.2 ppb	≤1 ppb	≤25 ppb	≤2 ppb

Typical filling pressure: 15 °C: 0.21 bar(a)/ 70 °F: -10.9 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Colourless liquid with a pungent odour. Hydrolyses in moist air to form hydrogen chloride and silicon dioxide. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP

Signal word: **WARNING**


H-statements:

EUH014 – Reacts violently with water; **H301** – Toxic is swallowed; **H331** – Toxic if inhaled; **H314** – Causes severe ski burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods

ADR Class 8, C1

DOT Class 8

CHEM MANUF METAL R&D SEMI

Source

Silicon tetrachloride is commonly obtained by chlorination of ferrosilicon. Alternatively, silicon carbide or silicon dioxide/carbon mixtures are used as feedstock.

Silicon tetrachloride may also be obtained by reacting silicon with chlorine and hydrogen chloride.

Applications

Silicon tetrachloride is used as raw material/intermediate in the production of high purity silicon, silicon dioxide, polysilanes and other silicon-based substances.

Silicon tetrachloride is also used for surface treatment of metals and polymers.

Silicon tetrachloride can be used to produce smoke screens in warfare.

Silicon tetrachloride is used as starting material for manufacturing fused silica fibres.

Silicon tetrachloride can be used for chemical vapour deposition of silicon oxide, nitride or carbide layers.

Physical data

Molecular weight		169.89		
Boiling point	at 1.013 bar [°C]	57.6	at 14.5 psi [°F]	135.7
Density	at 1.013 bar, 15 °C [kg/m^3]	7.733	at 1 atm., 70 °F [lb/ft^3]	0.483
Vapour pressure	at 0 °C [bar]	0.10	at 32 °F [psi]	1.47
	at 20 °C [bar]	0.26	at 70 °F [psi]	3.89
Flammability range in air [% volume]		Non combustible		

Silicon tetrafluoride SiF_4

Tetrafluorosilane

CAS: 7783-61-1
EC: 232-015-5
UN: 1859

Purity grade	Typical purity	Typical impurities [ppm]				
		O_2	N_2	CO_2	CO	CH_4
HiQ® Silicon tetrafluoride 4.8	≥99.998 %	≤3	≤3	≤3	≤3	≤10

Typical filling pressure: 15 °C: 63 bar(a)/70 °F: 900 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Liquefied and colourless gas with a pungent odour. Hydrolyses in moist air to form hydrogen fluoride and silicon dioxide. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

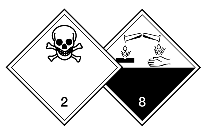
Proposed by the Industry

Signal word: DANGER

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H330 – Fatal if inhaled; H314 – Causes severe skin burns and eye damage; EUH071 – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

CHEM ENERGY METAL R&D SEMI

Source

Silicon tetrafluoride is commercially extracted as a by-product of the exhaust gases from phosphate fertiliser production.

Silicon tetrafluoride is obtained by treating silicon dioxide and calcium fluoride with concentrated sulfuric acid.

Silicon tetrafluoride is alternatively produced by heating barium hexafluorosilicate.

Applications

Silicon tetrafluoride is used to produce sodium hexafluoroaluminate (synthetic cryolite) and aluminium fluoride.

Silicon tetrafluoride is used as a silicon source in the manufacture of optical fibres.

Silicon tetrafluoride is used for water fluorination.

Silicon tetrafluoride is used for low temperature silicon deposition and for plasma etching of aluminium in the semiconductor industry.

Silicon tetrafluoride is used in organic synthesis.

Physical data

Molecular weight		104.08		
Boiling point	at 1.013 bar [°C]	–95.14	at 14.5 psi [°F]	–139.25
Density	at 1.013 bar, 15 °C [kg/m³]	4.431	at 1 atm., 70 °F [lb/ft³]	0.271
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Sulfur dioxide SO_2

CAS: 7446-09-5
EC: 231-195-2
UN: 1079

Purity grade	Typical purity	Typical impurities [ppm]					
		Moisture (water)	Acidity	Non volatile residue	Halogene	Organic substances	Heavy metals
Sulfur dioxide 3.0	≥99.9 %	contact local team					
HiQ® Sulfur dioxide 3.8	≥99.98 %	≤50 ppm	≤10 ppm	≤50 ppm	≤1 ppm	≤1 ppm	≤1 ppm
Sulfur dioxide E220 (food grade)	≥99.98 %	≤50 ppm	≤10 ppm	≤50 ppm	≤1 ppm	≤1 ppm	≤1 ppm

Typical filling pressure: 15 °C: 2.8 bar(a)/70 °F: 34 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, liquefied gas with pungent odour. Dry gas is not corrosive. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

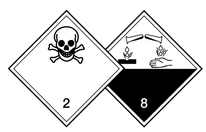
GHS-CLP

Signal word: DANGER

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **H331** – Toxic if inhaled; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 2, 2TC

DOT Class 2.3

AUTO CHEM ENERGY FOOD MANUF METAL PETRO PHARMA R&D

Source

Sulfur dioxide may be produced by a variety of routes, such as the combustion of sulfur or pyrites. Alternatively, it is gained as a by-product of smelter operations.

Sulfur dioxide is commonly obtained by burning sulfur with oxygen. It is primarily produced for sulfuric acid manufacture.

Applications

Sulfur dioxide is used in the manufacture of sulfite, hydrogen sulfites and sulfuric acid.

Sulfur dioxide is used in magnesium foundries as protection gas (an alternative to SF_6).

Sulfur dioxide is used as an antioxidant for certain types of dried food, and also to bleach glue, sugar, textiles, fats and oils.

Sulfur dioxide is used to sterilise wine and beer making equipment in order to inhibit the growth of moulds and bacteria, and to control wine fermentation. Sulfur dioxide may be used in a variety of disinfecting and fumigation applications.

For any of the food and sterilisation applications above, registration/authorisation may be needed to comply with local legal requirements on biocidal products.

Sulfur dioxide is used as a component in environmental calibration gases.

Sulfur dioxide may be used:
- → as a refrigerant
- → in laboratory research on corrosion problems
- → to remove excess chlorine in textile bleaching and water treatment
- → in preparation of chrome leather tanning
- → as a solvent.

Sulfur dioxide is used in the pharmaceutical industry as a reaction agent.

Sulfur dioxide is used in gas mixtures for car emission monitoring.

Sulfur dioxide is also used in the float glass manufacturing process.

Physical data

Molecular weight		64.065		
Boiling point	at 1.013 bar [°C]	−10.02	at 14.5 psi [°F]	13.98
Density	at 1.013 bar, 15 °C [kg/m^3]	2.759	at 1 atm., 70 °F [lb/ft^3]	0.169
Vapour pressure	at 0 °C [bar]	1.55	at 32 °F [psi]	22.51
	at 20 °C [bar]	3.36	at 70 °F [psi]	50.67
Flammability range in air [% volume]		Non combustible		

Sulfur hexafluoride SF_6

CAS: 2551-62-4
EC: 219-854-2
UN: 1080

Purity grade	Typical purity	Typical impurities [ppm]					
		Air	H_20	$0_2 + N_2$	CF_4	Acidity (HF)	Hydrolysable fluoride
Sulfur hexafluoride 3.0	≥99.9 %	≤500 ppm(w)	≤5 ppm(w)	-	≤500 ppm(w)	≤0.3 ppm(w)	≤1 ppm(w)
HiQ® Sulfur hexafluoride 4.5	≥99.995 %	-	≤5	≤10	≤40	≤0.5 ppm(w)	-
HiQ® Sulfur hexafluoride 4.8	≥99.998 %	-	≤2	≤5	≤15	≤0.5 ppm(w)	-
HiQ® Sulfur hexafluoride 5.0	≥99.999 %	-	≤1	≤5	≤5	≤0.1 ppm(w)	-

Typical filling pressure: 15 °C: 19 bar(a)/ 70 °F: 320 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics
Colourless and odourless gas. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

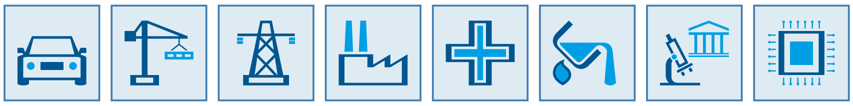
Proposed by the Industry
Signal word: **WARNING**

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2



Source

Sulfur hexafluoride is manufactured by direct fluorination of pure (elemental) sulfur, generally by companies which produce fluorine for other purposes such as the production of fluorocarbons.

Depending on the purity grade needed, further purification steps like distillation or extraction are applied.

Applications

A major application of sulfur hexafluoride is using the gas as a dielectric medium/insulator in circuit breakers, switch gears, power substations and gas-insulated transmission lines. For these applications, the gas used must meet or exceed ASTM D2472 and IEC specifications.

Sulfur hexafluoride is used as a plasma etching gas.

Sulfur hexafluoride is often used as a filling gas in double glazing to reduce sound transmissions and heat transfer.

Certain HF/DF chemical lasers (see page XXX) use sulfur hexafluoride as fluorine source. This type of laser is typically used in R&D applications.

As sulfur hexafluoride is both inert and considerably denser than air, it is suitable for blanketing open baths of certain molten metals, particularly magnesium.

Sulfur hexafluoride is used in laboratories as a carrier gas medium in supercritical fluid chromatography (SFC), and as a medium in supercritical fluid extraction (SFE) for sample preparation.

Sulfur hexafluoride is being used for medical purposes such as a contrasting agent for ultrasonic examinations, and in retinal surgery. If classified as a medical device in a geography, sulfur hexafluoride will be managed according to the relevant local regulations.

Sulfur hexafluoride is used in a wide variety of applications as a leak detection gas. Typically it is employed in testing aluminium beer barrels, water supply pipelines or parts of airplanes and automobiles.

Sulfur hexafluoride is also used:
→ as filling in loudspeakers
→ as tyre filling gas.

Sulfur hexafluoride is also used as tracer gas to test the effectiveness of ventilation systems.

Note:
Sulfur hexafluoride is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		146.06		
Boiling point	at 1.013 bar [°C]	−63.9	at 14.5 psi [°F]	−83.0
Density	at 1.013 bar, 15 °C [kg/m^3]	6.261	at 1 atm., 70 °F [lb/ft^3]	0.382
Vapour pressure	at 0 °C [bar]	12.90	at 32 °F [psi]	187.2
	at 20 °C [bar]	21.60	at 70 °F [psi]	321.70
Flammability range in air [% volume]		Non combustible		

2,3,3,3-Tetrafluoro-1-propene $C_3H_2F_4$

Polyhaloalkene, HFO-1234yf, R-1234yf

CAS: 754-12-1
EC: 468-710-7
UN: 3161
R-1234yf

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
2,3,3,3-Tetrafluoro-1-propene	≥99.5 %	≤20 ppm(w)

Typical filling pressure: 15 °C: 5.1 bar(a)/70 °F: 85.1 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Flammable. Colourless liquefied gas with a faint smell. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: **DANGER**

H-statements:

H280 - Contains gas under pressure; may explode if heated; **H220** - Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM CONSTR FOOD PETRO

Source

2,3,3,3-tetrafluoro-1-propene can be synthesised by the catalytic pyrolysis of methyl chloride and either tetrafluoroethylene or chlorodifluoromethane (HCFC-22). It can also be produced by reacting tetrafluoroethylene, formaldehyde and HF in the presence of a TiF4 catalyst and limonene. Finally, a further process reacts HFO-1233xd with HF via two catalytic reactions.

Applications

2,3,3,3-tetrafluoro-1-propene is a next generation refrigerant gas. It is given the ASHRAE number R-1234yf. Whilst technically an HFC, it is often referred to as a sub-group, HFO, to distinguish its lower environmental impact. It is being chosen by many automotive OEMs as the low GWP refrigerant of choice, replacing HFC-134a.

Physical data

Molecular weight		114.04		
Boiling point	at 1.013 bar [°C]	-29	at 14.5 psi [°F]	-20.2
Density	at 1.013 bar, 25 °C [kg/m^3]	1.1	at 1 atm., 77 °F [lb/ft^3]	0.0687
Vapour pressure	at 0 °C [bar]	3.14	at 32 °F [psi]	45.5
	at 20 °C [bar]	5.87	at 70 °F [psi]	85.1
Flammability range in air [% volume]		6.2 – 12.3		

trans-1,3,3,3-Tetrafluoro-1-propene $C_3H_2F_4$

HFO-1234ze(E), R-1234ze

CAS: 29118-24-9
EC: 471-480-0
UN: 3163
R-1234ze

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
trans-1,3,3,3-Tetrafluoro-1-propene	≥99.5 %	≤50 ppm(w)

Typical filling pressure: 15 °C: 3.6 bar(a)/70 °F: 60.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless liquefied gas with an ether-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

H280 - Contains gas under pressure; may explode if heated.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CHEM CONSTR FOOD MANUF PETRO

Source

trans-1,3,3,3-tetrafluoro-1-propene can be synthesised by dehydrofluorination of 1,1,1,3,3-pentafluoropropane (HFC-245fa) using an alkaline solution or a gas phase catalysed process.

Applications

trans-1,3,3,3-tetrafluoro-1-propene (HFO-1234ze) is a next generation low global warming potential refrigerant and foam blowing agent. It is given the ASHRAE number R-1234ze(E). Whilst technically an HFC, it is often referred to as a sub-group, HFO, to distinguish its lower environmental impact.

Physical data

Molecular weight		114.04		
Boiling point	at 1.013 bar [°C]	-19	at 14.5 psi [°F]	-2.2
Density	at 1.013 bar, 21.1 °C [kg/m^3]	1.17	at 1 atm., 70 °F [lb/ft^3]	0.0730
Vapour pressure	at 0 °C [bar]	2.17	at 32 °F [psi]	31.4
	at 20 °C [bar]	4.19	at 70 °F [psi]	60.8
Flammability range in air [% volume]		Not combustible		

Tetrafluoroethane $C_2H_2F_4$

1,1,1,2-Tetrafluoroethane, Norflurane, R-134a

CAS: 811-97-2
EC: 212-377-0
UN: 3159
R-134a

Purity grade	Typical purity	Typical impurities [ppm]
Tetrafluoroethane 2.8	≥99.8 %	contact local team

Typical filling pressure: 15 °C: 4.9 bar(a) /70 °F: 110 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•		•			

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
Gaseous Withdrawal	Gaseous Withdrawal	Liquid Withdrawal	Consult local team

Characteristics

Colourless, odourless, liquefied gas. Can decompose to toxic substances at high temperatures. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry
Signal word: WARNING

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CONSTR MANUF PETRO PHARMA R&D

Source

Tetrafluoroethane is produced commercially by reacting hydrogen fluoride with Trichloroethylene.

Tetrafluoroethane can be manufactured by fractional distillation of the initial substances carbon tetrachloride and hydrofluoric acid.

Applications

Tetrafluoroethane (R-134a) and its mixtures are used as refrigerants in commercial, automotive and domestic refrigeration. Its use in automotive refrigeration is restricted in some geographies due to its global warming potential (Kyoto Protocol).

Tetrafluoroethane is also employed as a propellant in aerosols and also as a blowing agent for polymers, e.g. extruded polystyrene foams.

Pharma grade tetrafluoroethane is used in Metered Dose aerosol Inhalers (MDI).

Tetrafluoroethane is also used as reference medium in optical smoke detectors.

Tetrafluoroethane is employed in chemical extraction processes, liquid and supercritical, e.g. for fragrances.

Tetrafluoroethane is also used in cryogenic and astrophysics particle detectors.

Tetrafluoroethane can be used as an alternative shielding gas in magnesium smelting.

Note:

Tetrafluoroethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		102.03		
Boiling point	at 1.013 bar [°C]	−26	at 14.5 psi [°F]	−14.78
Density	at 1.013 bar, 15 °C [kg/m^3]	4.415	at 1 atm., 70 °F [lb/ft^3]	0.270
Vapour pressure	at 0 °C [bar]	2.92	at 32 °F [psi]	42.2
	at 20 °C [bar]	5.71	at 70 °F [psi]	85.7
Flammability range in air [% volume]		Non combustible		

Tetrafluoromethane CF_4

Carbon tetrafluoride, R-14

CAS: 75-73-0
EC: 200-896-5
UN: 1982
R-14

Purity grade	Typical purity	Typical impurities [ppm] H_2O	$O_2 + N_2$	O_2	N_2	$CO + CO_2$	CO	CO_2	Other halocarbons	Acidity
Tetrafluoromethane 2.8	≥99.8 %	contact local team								
HiQ® Tetrafluoromethane 3.5	≥99.95 %	≤5	≤400	-	-	≤10	-	-	≤100	≤1 ppm(w)
HiQ® Tetrafluoromethane 4.5	≥99.995 %	≤5	-	≤5	≤20	≤5	-	-	≤20	-
HiQ® Tetrafluoromethane 5.0	≥99.999 %	≤1	≤5	-	-	-	≤1	≤1	≤5	≤0.1 ppm(w)

Typical filling pressure: 15 °C: 110 bar(a)/70 °F: 2,000 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless, odourless, liquefied gas. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; **EIGA-As –** Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2, 2A

CHEM CONSTR MANUF R&D SEMI

Source

Tetrafluoromethane may be obtained by the direct fluorination of carbon (burning carbon in a fluorine atmosphere) or by an electrochemical process using acetic acid dissolved in liquid hydrogen fluoride.

Applications

Tetrafluoromethane (R-14) is used as a cryogenic fluid in low temperature refrigeration.

Tetrafluoromethane (R-14) is also used as:

- neutral, inert gas
- refrigerant
- heat transfer agent
- solvent
- propellant
- chemical intermediate.

Tetrafluoromethane is used, either pure or in mixture with oxygen, as an etchant for silicon oxide, silicon nitride, refractory metals and metal silicides.

Tetrafluoromethane is used in the electronics industry for plasma degreasing of multilayer printed circuit boards.

Tetrafluoromethane is used in the optical fibre production process.

Note:

Tetrafluoromethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		88.005		
Boiling point	at 1.013 bar [°C]	−128.06	at 14.5 psi [°F]	−198.49
Density	at 1.013 bar, 15 °C [kg/m^3]	3.737	at 1 atm., 70 °F [lb/ft^3]	0.228
Vapour pressure	at 0 °C [bar]	–	at 32 °F [psi]	–
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Trichlorosilane $SiHCl_3$

TCS

CAS: 10025-78-2
EC: 233-042-5
UN: 1295

Purity grade	Typical purity	Typical impurities [ppm]			
		$SiH_3Cl + SiH_2Cl_2$	C	B	Fe
HiQ® Trichlorosilane 3.5	≥99.95 % – Resistivity >600 Ω/cm	≤50 ppm	≤5 ppm	≤0.06 ppb	≤5 ppb

Typical filling pressure: 15 °C: 0.54 bar(a)/70 °F: -4.8 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
		•	Consult local team

Characteristics

Flammable. Colourless liquid with a sharp acidic odor. Highly corrosive in humid conditions. Vapour is heavier than air.

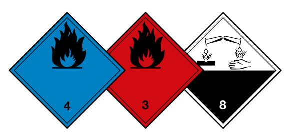
Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

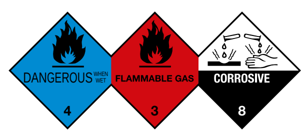
GHS-CLP
Signal word: DANGER

H-statements:
H224 – Extremely flammable liquid and vapour; **H250** – Catches fire spontaneously if exposed to air; **EUH014** – Reacts violently with water; **EUH029** – Contact with water liberates toxic gas; **H331** – Toxic if inhaled; **H302** – Harmful if swallowed; **H314** – Causes severe skin burns and eye damage; **EUH071** – Corrosive to the respiratory tract.

Transport of dangerous goods



ADR Class 4.3, WFC



DOT Class 4.3

CHEM R&D SEMI

Source

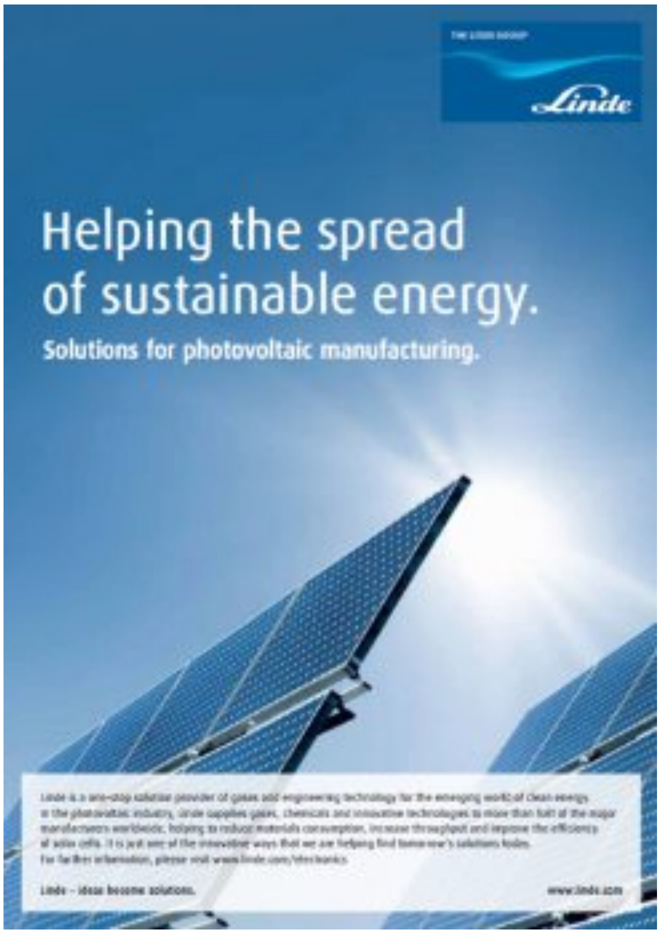
Trichlorosilane is commercially produced by reacting a ferrosilicon bed with hydrogen chloride at elevated temperature. Purification of trichlorosilane is usually achieved by distillation.

Trichlorosilane may also be obtained by a reaction of silicon, silicon tetrachloride and hydrogen.

Applications

Trichlorosilane is an intermediary material in the production of epitaxial wafers, polycrystalline silicon, silicone resin and organic chemical compounds.

Trichlorosilane is a precursor to organosilicon compounds, such as octadecyltrichlorosilane (OTS), perfluorooctyltrichlorosilane (PFOTCS) and perfluorodecyltrichlorosilane (FDTS) used for coating processes in surface science and in nano-technology, e.g. for micro-electrochemical systems (MEMS) and in nanoimprint lithography (NIL).



Physical data

Molecular weight		135.45		
Boiling point	at 1.013 bar [°C]	31.9	at 14.5 psi [°F]	89.4
Density	at 1.013 bar, 15 °C [kg/m^3]	6.016	at 1 atm., 70 °F [lb/ft^3]	0.366
Vapour pressure	at 0 °C [bar]	0.29	at 32 °F [psi]	4.17
	at 20 °C [bar]	0.66	at 70 °F [psi]	9.92
Flammability range in air [% volume]		1.2 – 90.5		

Trifluoroethane $C_2H_3F_3$

1,1,1-Trifluoroethane, HFC-143a, R-143a

CAS: 420-46-2
EC: 206-996-5
UN: 2035
R-143a

Purity grade	Typical purity	Typical impurities [ppm]
		H_2O
Trifluoroethane	≥99.8 %	≤50 ppm(w)

Typical filling pressure: 15 °C: 9.6 bar(a)/70 °F: 156.7 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Flammable. Colourless liquefied gas with a sweetish smell and slight odour warning effect at low concentration. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: DANGER

H-statements:

H280 - Contains gas under pressure; may explode if heated; H220 - Extremely flammable gas.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

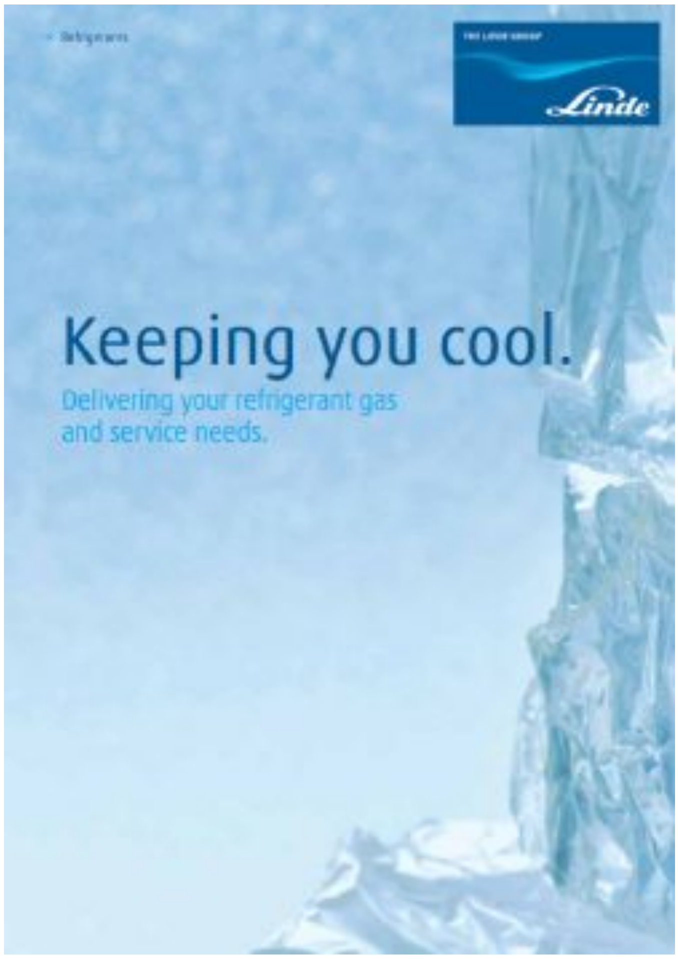
CHEM CONSTR FOOD PETRO

Source

Many HCFCs and HFCs are manufactured via similar synthesis routes from common feedstocks. A common synthesis route for trifluoroethane uses dichloroethylene, which is reacted with HF in the presence of a catalyst.

Applications

Trifluoroethane is used as a refrigerant gas. It is a hydrofluorocarbon (HFC) and is given the ASHRAE number R-143a. It is used either in pure form, or more commonly as a component of blended mixtures including R404A and R507A.



Note:

Trifluoroethane is listed in the Kyoto Protocol, an international framework convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		84.04		
Boiling point	at 1.013 bar [°C]	-47.4	at 14.5 psi [°F]	-53.3
Density	at 1.013 bar, 15 °C [kg/m^3]	3.564	at 1 atm., 60 °F [lb/ft^3]	0.2224
Vapour pressure	at 0 °C [bar]	6.2	at 32 °F [psi]	89.9
	at 20 °C [bar]	10.80	at 70 °F [psi]	156.7
Flammability range in air [% volume]		7.0 – 16.1		

Trifluoromethane CHF_3

Fluoroform, HFC-23, R-23

CAS: 75-46-7
EC: 200-872-4
UN: 1984
R-23

Purity grade	Typical purity	Typical impurities [ppm]					
		H_2O	$O_2 + N_2$	CO	CO_2	Other halocarbons	Acidity
Trifluoromethane 2.8	≥99.8 %	contact local team					
HiQ® Trifluoromethane 3.5	≥99.95 %	≤5	≤400	-	-	≤100	≤1 ppm(w)
HiQ® Trifluoromethane 4.8	≥99.998 %	≤1	≤5	≤1	≤10	≤5	≤0.1 ppm(w)
HiQ® Trifluoromethane 5.0	≥99.999 %	≤1	≤3	≤1	≤3	≤5	≤0.1 ppm(w)

Typical filling pressure: 15 °C: 37 bar(a)/70 °F: 635 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless, liquefied gas with an ethereal odour. Poor warning properties at low concentrations. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

Liquefied Gas → **H280** – Contains gas under pressure; may explode if heated; **EIGA-As** – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A

DOT Class 2.2

CONSTR MANUF R&D SEMI

Source

Trifluoromethane is obtained as a by-product of generating chlorodifluoromethane. Alternatively, it may be produced by reacting chloroform with hydrogen fluoride in the presence of a chromium catalyst.

Applications

Trifluoromethane (R-23) and its mixtures are used in low temperature refrigeration.

Trifluoromethane is used in plasma etching of silicon oxide or nitride layers in the semiconductor industry.

Trifluoromethane has been used as a fire suppressant.

Note:

Trifluoromethane is listed in the Kyoto Protocol, an international Framework Convention with the objective of reducing greenhouse gases.

Physical data

Molecular weight		70.014		
Boiling point	at 1.013 bar [°C]	–82.16	at 14.5 psi [°F]	–115.87
Density	at 1.013 bar, 15 °C [kg/m³]	2.986	at 1 atm., 70 °F [lb/ft³]	0.182
Vapour pressure	at 0 °C [bar]	24.94	at 32 °F [psi]	361.8
	at 20 °C [bar]	41.97	at 70 °F [psi]	625.6
Flammability range in air [% volume]		Non combustible		

Trimethylamine $(CH_3)_3N$

CAS: 75-50-3
EC: 200-875-0
UN: 1083

Purity grade	Typical purity	Typical impurities [ppm]
Trimethylamine 2.0	≥99 %	contact local team

Typical filling pressure: 15 °C: 1.6 bar(a)/70 °F: 27 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics
Flammable. Liquefied colourless gas with strong ammonia/fish-like odour. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

GHS-CLP
Signal word: DANGER

H-statements:
Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; H220 – Extremely flammable gas; H332 – Harmful if inhaled; H335 – May cause respiratory irritation; H315 – Causes skin irritation; H318 – Causes serious eye damage.

Transport of dangerous goods

ADR Class 2, 2F

DOT Class 2.1

CHEM MEDICAL PETRO PHARMA R&D

Source

Trimethylamine is prepared commercially either by a reaction of methanol and ammonia or by a reaction of a carbonyl compound and ammonia. Mono-, di and trimethylamine are formed in parallel in the same reaction. The three products are separated by distillation.

Applications

Trimethylamine is used in organic synthesis, in the manufacture of disinfectants, to prepare quaternary ammonium compounds, as a corrosion inhibitor, and in preparation of trimethylamine-borane addition compounds.

Trimethylamine is used in the chemical industry as an intermediate in the production of:
- insecticides
- wetting agents
- flotation agents
- disinfectants
- synthetic resins
- emulsifiers
- herbicides

Aqueous solutions containing 25% trimethylamine are employed in medical treatment as antihistamines.

Trimethylamine is used in manufacturing of:
- choline salts
- cationic starches
- intense sweeteners
- ion-exchange resins

Trimethylamine is used in the pharmaceutical industry for the preparation of active ingredients.

Physical data

Molecular weight		59.111		
Boiling point	at 1.013 bar [°C]	2.87	at 14.5 psi [°F]	37.19
Density	at 1.013 bar, 15 °C [kg/m^3]	2.59	at 1 atm., 70 °F [lb/ft^3]	0.158
Vapour pressure	at 0 °C [bar]	0.90	at 32 °F [psi]	13.04
	at 20 °C [bar]	1.83	at 70 °F [psi]	27.52
Flammability range in air [% volume]		2.0 – 11.6		

Xenon Xe

CAS: 7440-63-3
EC: 231-172-7
UN: 2036
UN: 2591 (Refrigerated liquid)

Purity grade	Typical purity	Typical impurities [ppm]									
		H_2O	O_2	C_nH_m	$CO + CO_2$	H_2	N_2	Ar	CF_4	Kr	C_2F_6
HiQ® Xenon 4.0	≥99.99 %	≤5	≤10	≤5	-	-	≤30	-	-	-	-
HiQ® Xenon 5.0	≥99.999 %	≤2	≤0.5	≤0.5	≤1	≤1	≤1	≤1	≤1	≤1	≤1

Typical filling pressure: 15 °C: 56 bar(a)/70 °F: 800 psi(g)

Typical packages

Cylinders	Bundles	Drum tanks	ISO tanks	Tube trailer	Road tanker
•					

Typical ancillary equipment

Pressure control valves	Gas distribution panels/manifolds	Liquid flow control valves	Customised distribution systems
•	•		Consult local team

Characteristics

Colourless and odourless gas. Non-reactive. Inert. Asphyxiant in high concentrations. Gas density is heavier than air.

Hazard classifications

Globally Harmonized System of classification of chemicals (GHS)

Proposed by the Industry

Signal word: WARNING

H-statements:

Liquefied Gas → H280 – Contains gas under pressure; may explode if heated; Refrigerated Gas → H281 – Contains refrigerated gas; may cause cryogenic burns or injury; EIGA-As – Asphyxiant in high concentrations.

Transport of dangerous goods

ADR Class 2, 2A (Compressed)
3A (Refrigerated liquid)

DOT Class 2.2

AUTO CHEM CONSTR MANUF MEDICAL OEM R&D SEMI

Source

Xenon is obtained from air separation plants. In view of its very low natural concentration in air, it is only economically viable to recover xenon from larger plants. In these cases a stream containing a mixture of crude xenon and krypton is extracted from the plant and processed in a separate purification and distillation system.

Applications

Xenon is used in some types of ion and excimer lasers. These are used for medical, semiconductor and industrial applications, and for research.

The major application for xenon is in the lighting industry. Both sodium and mercury lamps, which are used extensively for outdoor lighting, such as on motorways and other roads, are filled with pure xenon. Xenon is also used for:

- incandescent lamps
- iodine lamps (car headlights)
- arc lights
- flash bulbs
- cinema projection lamps
- Klieg lights for filming (sunlight simulation)
- illumination of large areas, e.g. sports grounds
- space simulations lamps

When mixed with oxygen, xenon is used in CAT (Computed Axial Tomography) scanners for blood flow mapping.

When mixed with methane, xenon is used as a fill gas for proportional counters and other types of radiation detectors (ionisation chambers, detection of radioactive iodine planted on the thyroid in the examination of tumours).

For neutron counters, a mixture with xenon and $^{10}BF_3$ is used.

It is also used for x- and γ-ray counters.

Xenon is used in a broad range of research programmes.

Xenon-based chemical compounds (fluoride, trioxide, perxenate) serve as fluorinating and oxidising agents in certain specific applications.

Xenon is also used for mass spectrometer calibration.

Xenon isotopes are used as trace markers in MRI (Magnetic Resonance Imaging) scans.

Xenon can be used as a general anaesthetic.

Xenon has been used by both European as well as NASA spacecraft as rocket fuel for small ion thrusters to position satellites in orbit.

Xenon can be used as purging gas in the etching production steps in chip production instead of argon. Due to the high cost, a xenon recovery system is necessary.

Physical data

Molecular weight		131.29		
Boiling point	at 1.013 bar [°C]	−108.12	at 14.5 psi [°F]	−162.60
Density	at 1.013 bar, 15 °C [kg/m³]	5.586	at 1 atm., 70 °F [lb/ft³]	0.341
Vapour pressure	at 0 °C [bar]	41.37	at 32 °F [psi]	600
	at 20 °C [bar]	–	at 70 °F [psi]	–
Flammability range in air [% volume]		Non combustible		

Appendix 01 - Material compatibility

Terms and definitions:

A = acceptable: material/gas combination that is safe under normal conditions of use
N = not acceptable: material/single gas combination that is not safe under all normal conditions of use
Blank space = There is no data provided in ISO 11114-1:2012 and ISO 11114-2:2013

Metallic materials (ISO 11114-1:2012):
AA = Aluminium alloys
Cu = Copper
SS = Austenitic type stainless steels
Ni = Nickel alloys

Non-metallic materials (ISO 11114-2:2013):
PTFE = Polytetrafluoroethylene
PA = Polyamide
PVC = Polyvinyl chloride
IIR = Butyl rubber
NBR = Nitrile rubber

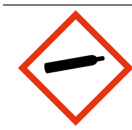
Gas	Metallic materials						Non-metallic materials: Plastics				Non-metallic materials: Elastomers			
	Aluminium	Brass	Carbon steel	Copper	Stainless steel	Nickel	Teflon®	Kel-F®	Nylon®	PVC	Butyl rubber	Buna® N	Neoprene®	Viton®
	AA	B	CS	Cu	SS	Ni	PTFE	PCTFE	PA	PVC	IIR	NBR	CR	FKM
Acetylene	A	A	A	N	A	A	A	A	A	A	A	N	N	N
Air, synthetic**	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Ammonia	A	N	A		A	A	A	A	A	A	A	N	A	N
Argon	A	A	A		A		A	A	A	A	A	A	A	A
Arsine	A	A	A		A	A	A	A	A	A	A	A	A	A
Boron trichloride	N	N	A		A	A	A	A	N	A	N	N	N	A
Boron trifluoride	N	N	A		A	A	A	A	N	A	N	N	N	A
1,3-Butadiene	A	A	A		A		A	A	A	A	N	N	N	A
n-Butane	A	A	A		A		A	A	A	A	N	A	A	A
iso-Butane	A	A	A		A		A	A	A	A	N	A	A	A
1-Butene	A	N	A		A									
cis-2-Butene	A	A	A		A									
iso-Butene							A	A	A	N	N	A	N	N
trans-2-Butene	A	A	A		A									
Carbon dioxide	A	A	A		A		A	A	A	A	N	N	N	N
Carbon monoxide	A	A	A		A		A	A	A	A	A	A	A	N
Carbonyl fluoride							A	A	N	N	A	A	N	A
Carbonyl sulfide	A	A	A		A		A	A	A	A	N	N	N	A
Chlorine	N	A	A		A		A	A	N	N	N	N	N	A
Chlorodifluoromethane	A	A	A		A		A	A	A	N	A	N	A	N
Chloropentafluoroethane							A	A	A	N	A	A	A	A
Cyclopropane	A	A	A		A		A	A	A	A	N	A	N	A
Deuterium	A	A	A		A		A	A	A	A	A	A	A	A
Diborane	A	A	A		A	A	A	A	A	A	A	A	A	A
Dichlorodifluoromethane	A	A	A		A		A	A	A	N	N	N	A	A
1,1-Dichloro-1-fluoroethane							A	A	A	N	N	N	N	N
Dichlorofluoromethane	A	A	A		A		A	A	A	N	N	N	N	N
Dichlorosilane	N	N	A		A	A	A	A	N	N	N	N	N	A
1,2-Dichlorotetrafluoroethane	A	A	A		A									
1,1-Difluoroethane	A	A	A		A									
1,1-Difluoroethylene	A	A	A		A									
Dimethyl ether	A	A	A		A		A	A	N	N	N	N	N	N
Dimethylamine	A	N	A		A		A	A	A	N	A	N	N	N

Gas	Metallic materials						Non-metallic materials: Plastics				Non-metallic materials: Elastomers			
	Aluminium	Brass	Carbon steel	Copper	Stainless steel	Nickel	Teflon®	Kel-F®	Nylon®	PVC	Butyl rubber	Buna® N	Neoprene®	Viton®
	AA	B	CS	Cu	SS	Ni	PTFE	PCTFE	PA	PVC	IIR	NBR	CR	FKM
Ethane	A	A	A		A		A	A	A	A	N	A	N	A
Ethanedinitrile	A	N	A		A	A	A	A	A		N	N	N	A
Ethylamine	A	N	A		A	A	A	A	N	N	N	N	N	N
Ethylene	A	A	A		A		A	A	A	A	A	A	A	A
Ethylene oxide	A	A	A		A		A	A	N	N	N	N	N	N
Fluorine	N	A	A		A	A	N	N	N	N	N	N	N	N
Fluoromethane	A	A	A		A									
Helium	A	A	A		A		A	A	A	A	A	A	A	A
1,1,1,2,3,3,3-Heptafluoropropane							A	A	A	A	A	A	A	A
Hexafluoroethane							A	A	A	N	N	N	N	A
Hydrogen	A	A	A		A		A	A	A	A	A	A	A	A
Hydrogen bromide	N	N	A		A	A	A	A	N	A	N	N	N	A
Hydrogen chloride	N	N	A		A	A	A	A	N	A	N	N	N	A
Hydrogen cyanide	A	A	A		A		A	A	N	A	N	N	N	A
Hydrogen fluoride	N	N	A		A	A	A	A	N	A	N	N	N	A
Hydrogen iodide	N	N	A		A	A	A	A	N	A	N	N	N	A
Hydrogen sulfide	A	N	A		A		A	A	A	A	A	N	N	N
Krypton	A	A	A		A		A	A	A	A	A	A	A	A
Methane	A	A	A		A		A	A	A	A	N	A	A	A
Methylamine	A	N	A		A	A	A	A	A	N	A	N	N	N
Neon	A	A	A		A		A	A	A	A	A	A	A	A
Nitric oxide	N	N	A		A		A	A	N	N	N	N	N	A
Nitrogen	A	A	A		A		A	A	A	A	A	A	A	A
Nitrogen dioxide	N	N	A		A		A	A	N	N	N	N	N	N
Nitrogen trifluoride	A	A	A		A		A	A	N	N	N	N	N	A
Nitrous oxide	A	A	A		A		A	A	A	N	N	N	N	N
Octafluoropropane	A	A	A		A		A	A	A	N	A	A	A	A
Oxygen***														
Pentafluoroethane							A	A	A	A	A	A	A	A
Phosgene	N	A	A		A		A	A	N	N	A	A	N	A
Phosphine	A	A	A		A		A	A	N	A	A	A	A	A
Propadiene	A	A	A		A		A	A	N	A	A	N	N	A
Propane	A	A	A		A		A	A	A	N	N	A	N	A
Propylene	A	A	A	N	A		A	A	A	N	N	N	N	A
Silane	A	A	A		A		A	A						
Silicon tetrachloride	N	A	A		A		A	A	N	N	N	N	N	A
Silicon tetrafluoride	N	A	A		A		A	A	N	N	N	N	N	N
Sulfur dioxide	A	A	A		A	A	A	A	N	N	A	N	N	N
Sulfur hexafluoride	A	A	A		A									
Tetrafluoromethane							A	A	A	N	N	N	N	A
Trichlorosilane	N	A	A		A	A	A	A	N	N	N	N	N	A
Trifluoroethane	A	A	A		A		A	A	N	N	N	N	N	A
Trifluoromethane	N	A	A		A									
Trimethylamine	A	N	A		A	A	A	N	N	A	A	A	N	N
Xenon	A	A	A		A		A	A	A	A	A	A	A	A

** - Not referenced in ISO 11114 - 1:2012

*** - Please consult your local Linde representative

Appendix 02 - GHS safety symbols and hazard statements

PHYSICAL HAZARDS	Old EC Classification[1]		New GHS-CLP Classification[2]		
	Symbol	R-phrases	Symbol	Signal word	H-statements
EXPLOSIVE		(R2, R3)		DANGER	H200 H201, H202, H203 H240, H241
	No symbol	No phrase		WARNING	H204
FLAMMABLE	No symbol	R10		WARNING	H221, H223, H226
		R11		DANGER WARNING	H225, H228 (cat.1), H228 (cat.2)
		R12		DANGER	H220, H222, H224
CHEMICALLY UNSTABLE		R6 R5		No additional signal word	H230 H231
PYROPHORIC SELF HEATING		R17		DANGER	H250
		(R15)		DANGER WARNING	H260, H261 (cat.2) H261(cat.3)
		R12		DANGER WARNING	H241, H242 (type C,D), H251 H242 (type E,F), H252
ORGANIC PEROXIDE		R7		DANGER WARNING	H241, H242 (type C,D), H242 (type E,F)
OXIDISING		R8		DANGER	H250
		R8, R9		DANGER WARNING	H271, H272 (cat.2), H272 (cat.3)
GASES UNDER PRESSURE	No symbol	No phrase		WARNING	H280 H281
CORROSIVE TO METALS	No symbol	No phrase		WARNING	H290

[1]EC: Directive 67/548/EEC
[2]GHS-CLP: Globally Harmonized System for Classification & Labelling – Regulation (EC) No 1272/2008

		Old EC Classification[1]				New GHS-CLP Classification[2]				
		Symbol	R-phrases			Symbol	Signal word	H-statements		
HEALTH HAZARDS	TOXIC		R28	R27	R26		DANGER	H300	H310	H330
			R25	R24	R23			H301	H311	H331
	CARCINOGENIC MUTAGENIC TOXIC FOR REPR.		R46	R45, R49			DANGER	H340	H350	
			R39	R60, R61				H370	H360	
			R48					H372		
	HARMFUL	No symbol	No phrase					H304		
			R42					H334		
			R65				WARNING	H305		
			R68		R40			H371, H373		H351
			R48	R62, R63				H373	H361	
			R64			No symbol	No signal word	H362		
			R22	R21	R20		WARNING	H302	H312	H332
	CORROSIVE		R34, R35				DANGER	H314		
	IRRITANT		R41					H318		
			R38	R36	R43		WARNING	H315	H319	H317
			R37					H335		
		No symbol	R67					H336		
ENVIRONMENTAL HAZARDS	HAZARDOUS TO AQUATIC ENVIRONMENT		R50	R50/53			WARNING	H400	H400, H410	
			R51/53				No signal word	H411		
	HAZARDOUS TO OZONE LAYER		R59				WARNING	H420		

Appendix 02 - GHS safety symbols and hazard statements

R-phrases	
R1	Explosive when dry
R2	Risk of explosion by shock, friction, fire or other sources of ignition
R3	Extreme risk of explosion by shock, friction, fire or other sources of ignition
R4	Forms very sensitive explosive metallic compounds
R5	Heating may cause an explosion
R6	Explosive with or without contact with air
R7	May cause fire
R8	Contact with combustible material may cause fire
R9	Explosive when mixed with combustible material
R10	Flammable
R11	Highly flammable
R12	Extremely flammable
R14	Reacts violently with water
R15	Contact with water liberates extremely flammable gases
R16	Explosive when mixed with oxidising substances
R17	Spontaneously flammable in air
R18	In use, may form flammable/explosive vapour-air mixture
R19	May form explosive peroxides
R20	Harmful by inhalation
R21	Harmful in contact with skin
R22	Harmful if swallowed
R23	Toxic by inhalation
R24	Toxic in contact with skin
R25	Toxic if swallowed
R26	Very toxic by inhalation
R27	Very toxic in contact with skin
R28	Very toxic if swallowed
R29	Contact with water liberates toxic gas
R30	Can become highly flammable in use
R31	Contact with acids liberates toxic gas
R32	Contact with acids liberates very toxic gas
R33	Danger of cumulative effects

R-phrases	
R34	Causes burns
R35	Causes severe burns
R36	Irritating to eyes
R37	Irritating to respiratory system
R38	Irritating to skin
R39	Danger of very serious irreversible effects
R40	Limited evidence of a carcinogenic effect
R41	Risk of serious damage to eyes
R42	May cause sensitisation by inhalation
R43	May cause sensitisation by skin contact
R44	Risk of explosion if heated under confinement
R45	May cause cancer
R46	May cause inheritable genetic damage
R48	Danger of serious damage to health by prolonged exposure
R49	May cause cancer by inhalation
R50	Very toxic to aquatic organisms
R51	Toxic to aquatic organisms
R52	Harmful to aquatic organisms
R53	May cause long-term adverse effects in the aquatic environment
R54	Toxic to flora
R55	Toxic to fauna
R56	Toxic to soil organisms
R57	Toxic to bees
R58	May cause long-term adverse effects in the environment
R59	Dangerous for the ozone layer
R60	May impair fertility
R61	May cause harm to the unborn child
R62	Possible risk of impaired fertility
R63	Possible risk of harm to the unborn child
R64	May cause harm to breast-fed babies
R65	Harmful: may cause lung damage if swallowed
R66	Repeated exposure may cause skin dryness or cracking
R67	Vapours may cause drowsiness and dizziness
R68	Possible risk of irreversible effects

H-statements	
H200	Unstable explosive
H201	Explosive; mass explosion hazard
H202	Explosive; severe projection hazard
H203	Explosive; fire, blast or projection hazard
H204	Fire or projection hazard
H205	May mass explode in fire
H220	Extremely flammable gas
H221	Flammable gas
H222	Extremely flammable aerosol
H223	Flammable aerosol
H224	Extremely flammable liquid and vapour
H225	Highly flammable liquid and vapour
H226	Flammable liquid and vapour
H227	Combustible liquid
H228	Flammable solid
H229	Pressurised container: may burst if heated
H230	May react explosively even in the absence of air
H231	May react explosively even in the absence of air at elevated pressure and/or temperature
H240	Heating may cause an explosion
H241	Heating may cause a fire or explosion
H242	Heating may cause a fire
H250	Catches fire spontaneously if exposed to air
H251	Self-heating; may catch fire
H252	Self-heating in large quantities; may catch fire
H260	In contact with water releases flammable gases which may ignite spontaneously
H261	In contact with water releases flammable gas
H270	May cause or intensify fire; oxidiser
H271	May cause fire or explosion; strong oxidiser
H272	May intensify fire; oxidiser
H280	Contains gas under pressure; may explode if heated
H281	Contains refrigerated gas; may cause cryogenic burns or injury
H290	May be corrosive to metals
H300	Fatal if swallowed
H301	Toxic if swallowed
H302	Harmful if swallowed
H303	May be harmful if swallowed
H304	May be fatal if swallowed and enters airways
H305	May be harmful if swallowed and enters airways
H310	Fatal in contact with skin

H-statements	
H311	Toxic in contact with skin
H312	Harmful in contact with skin
H313	May be harmful in contact with skin
H314	Causes severe skin burns and eye damage
H315	Causes skin irritation
H316	Causes mild skin irritation
H317	May cause an allergic skin reaction
H318	Causes serious eye damage
H319	Causes serious eye irritation
H320	Causes eye irritation
H330	Fatal if inhaled
H331	Toxic if inhaled
H332	Harmful if inhaled
H333	May be harmful if inhaled
H334	May cause allergy or asthma symptoms or breathing difficulties if inhaled
H335	May cause respiratory irritation
H336	May cause drowsiness or dizziness
H340	May cause genetic defects
H341	Suspected of causing genetic defects
H350	May cause cancer
H351	Suspected of causing cancer
H360	May damage fertility or the unborn child
H361	Suspected of damaging fertility or the unborn child
H361d	Suspected of damaging the unborn child
H362	May cause harm to breast-fed children
H370	Causes damage to organs
H371	May cause damage to organs
H372	Causes damage to organs through prolonged or repeated exposure
H373	May cause damage to organs through prolonged or repeated exposure
H400	Very toxic to aquatic life
H401	Toxic to aquatic life
H402	Harmful to aquatic life
H410	Very toxic to aquatic life with long lasting effects
H411	Toxic to aquatic life with long lasting effects
H412	Harmful to aquatic life with long lasting effects
H413	May cause long lasting harmful effects to aquatic life
H420	Harms public health and the environment by destroying ozone in the upper atmosphere

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CAS numbers

EC numbers

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200-813-2; See Methyl bromide
200-814-8; See Ethane
200-815-3; See Ethylene
200-816-9; See Acetylene
200-817-4; See Methyl chloride
200-820-0; See Methylamine
200-821-6; See Hydrogen cyanide
200-822-1; See Methyl mercaptan
200-827-9; See Propane
200-828-4; See Propyne
200-830-5; See Ethyl chloride
200-831-0; See Chloroethene
200-834-7; See Ethylamine
200-839-4; See Difluoromethane
200-847-8; See Cyclopropane
200-849-9; See Ethylene oxide
200-857-2; See iso-Butane
200-866-1; See Difluoroethane
200-867-7; See 1,1-Difluoroethylene
200-869-8; See Dichlorofluoromethane
200-869-8; See Dichlorotetrafluoroethane
200-870-3; See Phosgene
200-871-9; See Chlorodifluoromethane
200-872-4; See Trifluoromethane
200-875-0; See Trimethylamine
200-891-8; See Chlorodifluoroethane
200-893-9; See Dichlorodifluoromethane
200-896-5; See Tetrafluoromethane
200-938-2; See Chloropentafluoroethane
200-939-8; See Hexafluoroethane
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203-449-2; See 1-Butene
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203-451-3; See 1-Butyne
203-475-4; See Methyl vinyl ether
203-481-7; See Methyl formate
203-692-4; See n-Pentane
203-721-0; See Ethyl formate
204-062-1; See Propylene
204-065-8; See Dimethyl ether
204-066-3; See iso-Butene
204-696-9; See Carbon dioxide
204-697-4; See Dimethylamine
206-016-6; See Cyclopentane
206-190-3; See 2,2-Dichloro-1,1,1-trifluoroethane
206-557-8; See Pentafluoroethane
206-534-2; See Carbonyl fluoride
206-996-5; See Trifluoroethane
207-079-2; See 1,1,1,2,3,3,3-Heptafluoropropane
207-306-5; See Ethanedinitrile
207-335-3; See Propadiene
207-340-0; See Carbonyl sulfide
207-343-7; See 2,2-Dimethylpropane
208-052-8; See Cyanic chloride
209-673-7; See cis-2-Butene
209-796-6; See Fluoromethane
209-800-6; See Bromoethylene
210-855-3; See trans-2-Butene
211-128-3; See Carbon monoxide
212-377-0; See Tetrafluoroethane
215-605-7; See Hydrogen
219-854-2; See Sulfur hexafluoride
220-629-6; See 1-Chloro-1,2,2,2-tetrafluoroethane
223-888-3; See Dichlorosilane
231-098-5; See Krypton
231-110-9; See Neon
231-147-0; See Argon
231-168-5; See Helium
231-172-7; See Xenon
231-195-2; See Sulfur dioxide
231-569-5; See Boron Trifluoride
231-595-7; See Hydrogen chloride
231-634-8; See Hydrogen fluoride
231-635-3; See Ammonia
231-783-9; See Nitrogen
231-952-7; See Deuterium
231-954-8; See Fluorine
231-956-9; See Oxygen
231-959-5; See Chlorine
231-977-3; See Hydrogen sulfide
232-007-1; See Nitrogen trifluoride
232-015-5; See Silicon tetrafluoride
232-066-3; See Arsine
232-260-8; See Phosphine
232-263-4; See Silane
233-032-0; See Nitrous oxide
233-042-5; See Trichlorosilane
233-054-0; See Silicon tetrachloride
233-109-9; See Hydrogen iodide
233-113-0; See Hydrogen bromide
233-271-0; See Nitric oxide
233-272-6; See Nitrogen dioxide
233-658-4; See Boron Trichloride
242-940-6; See Diborane
404-080-1; See 1,1-Dichloro-1-fluoroethane
419-170-6; See 1,1,1,3,3-Pentafluoropropane
425-320-1; See 1,1,1,3,3,3-Hexafluoropropane
468-710-7; See 2,3,3,3-Tetrafluoro-1-propene
471-480-0; See trans-1,3,3,3-Tetrafluoro-1-propene

UN numbers

R numbers

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages, and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardized as well as customized solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimization, and enhanced productivity are part of daily business. We define partnership not merely as being there for you, but being with you. After all, joint activities form the core of commercial success.

Linde – Making our world more productive.

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