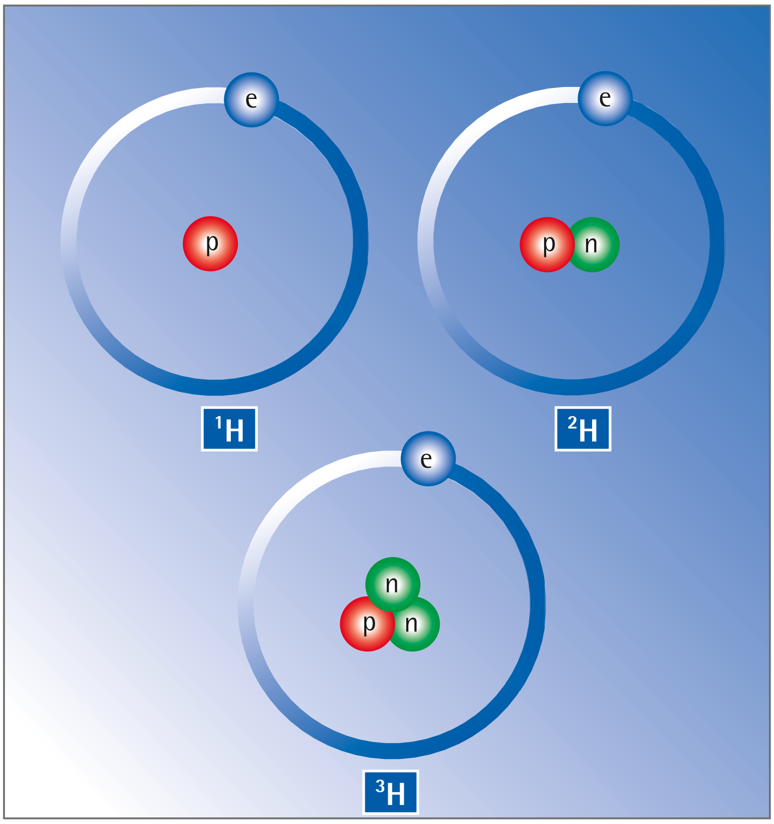
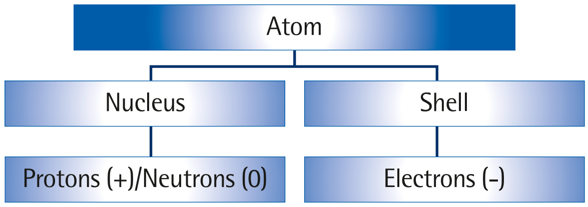
Nuclear Species: Isotopes.



The three isotopes of hydrogen: protium (^{1}H, top left), deuterium (^{2}H, top right), tritium (^{3}H, bottom).

Isotopes are nuclear species - known as nuclides – that have the same atomic number but a different mass number. The term derives from the Greek: "isos" = equal, "topos" = place, position. The term refers to the fact that isotopes of an element are not declared separately in the periodic table but are grouped together "in the same place" - even though despite having the same number of protons, the number of neutrons varies.



Almost every naturally occurring element has at least one stable isotope. The other nuclides are unstable and decay over time. There are however also elements which only have unstable - in other words radioactive - nuclear species.

The various isotopes of an element are identified by means of the mass number, which appears at upper left of the element symbol. Oxygen's isotopes, for example, appear like this: $^{16}O_2$, $^{17}O_2$, $^{18}O_2$.

Hydrogen – the exception.

By contrast to other isotopes, the three nuclides of hydrogen each have individual names:

- **Protium** is the most commonly occurring isotope of hydrogen, ^{1}H, and is also known as "light hydrogen".
- The ^{2}H isotope goes under the name of **Deuterium** (element symbol D). Deuterium is also known as "heavy hydrogen".
- **Tritium** (element symbol T) is the name for "superheavy hydrogen": the ^{3}H isotope.

Isotopes in practice.

Modern analytical and diagnostic techniques in particular are only made possible by the selective use of various isotopes. Examples include:

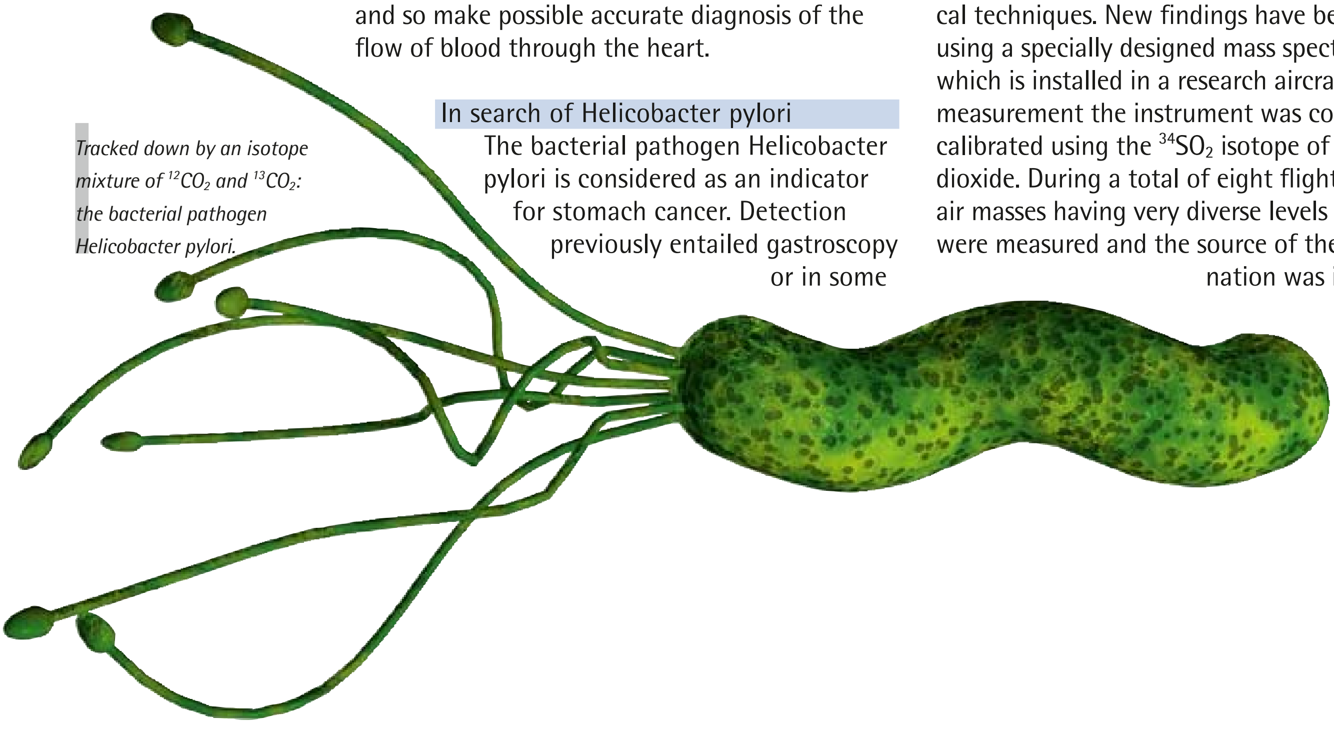
Positron Emission Tomography (PET)

An isotope mixture comprising 2.5 percent by volume of $^{16}O_2$ in $^{15}N_2$ is key to positron emission tomography. $^{15}N_2$ is transformed into unstable $^{15}O_2$ in a particle accelerator – the so-called cyclotron. Reaction with hydrogen produces unstable, radioactive water ($H_2{}^{15}O$), which is administered intravenously to the patient. Having a half life of just a few minutes, the rapidly decaying positron emitters can be measured by PET and so make possible accurate diagnosis of the flow of blood through the heart.

A mixture of oxygen and nitrogen isotopes is employed in the cyclotron in positron emission tomography.

In search of Helicobacter pylori

The bacterial pathogen Helicobacter pylori is considered as an indicator for stomach cancer. Detection previously entailed gastroscopy or in some cases even complex surgical intervention. Using certain mixtures of isotopes, however, diagnosis can now be obtained by means of a simple breath test. Helicobacter pylori converts the carbon contained in urea into carbon dioxide. The metabolic reaction converts a ^{13}C isotope into a stable $^{13}CO_2$ isotope, which is released with the breath. Specially calibrated mixtures of $^{12}CO_2$ and $^{13}CO_2$ serve as zero and reference gases for the mass spectroscopy techniques employed in diagnosis.



Tracked down by an isotope mixture of $^{12}CO_2$ and $^{13}CO_2$: the bacterial pathogen Helicobacter pylori.

Measuring air contamination

Air pollution from process gases such as sulphur dioxide can be measured and traced via analytical techniques. New findings have been obtained using a specially designed mass spectrometer which is installed in a research aircraft. During measurement the instrument was continuously calibrated using the $^{34}SO_2$ isotope of sulphur dioxide. During a total of eight flights, various air masses having very diverse levels of pollution were measured and the source of the contamination was identified.

Our range: Isotopes from Westfalen.

Stable natural isotopes are available from Westfalen as high purity gases or as mixtures. Our range includes, for example:

- Deuterium
- ^{3}Helium
- ^{15}Nitrogen
- ^{18}Oxygen
- ^{15}Dinitrogen monoxide
- ^{12}Carbon dioxide
- ^{13}Carbon dioxide
- ^{13}Carbon monoxide
- ^{34}Sulphur dioxide
- ^{15}Ammonia
- Deuterated ammonia
- Isotopes of the noble gases neon, krypton, xenon
- Other high purity gas isotopes available on request

We prepare isotope mixtures gravimetrically according to your specific requirements.

Isotope shifts.

Deviations in the defined isotope compositions of chemical elements are also stated as delta shifts. Defined compositions include, for example:

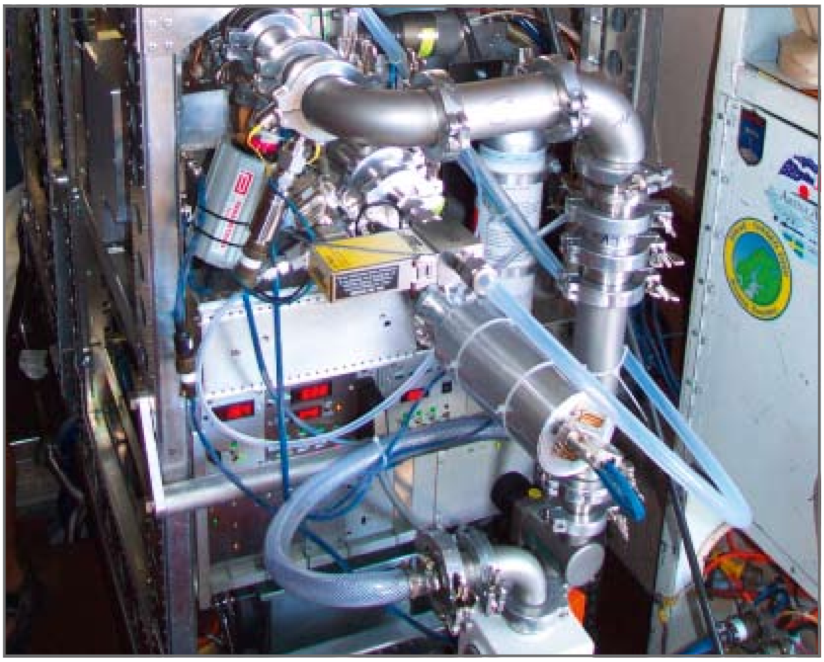
Element	Measured proportion (R)	International standard	R, international standard
Hydrogen	$^{2}H/^{1}H$	SMOW (Standard Mean Ocean Water)	0.00015575
Carbon	$^{13}C/^{12}C$	PDB (Pee Dee Belemnite)	0.0112372
Oxygen	$^{18}O/^{16}O$	SMOW (Standard Mean Ocean Water)	0.0020052
Oxygen	$^{18}O/^{16}O$	PDB (Pee Dee Belemnite)	0.0020672
Sulphur	$^{34}S/^{32}S$	CDT (Canon Diablo Troilite)	0.0450045
Sulphur	$^{34}S/^{32}S$	VCDT (Vienna Canon Diablo Troilite)	0.044163

The isotope shift in the samples compared to the corresponding standards, normally stated in parts per thousand, is calculated as:

$$\partial_{shift} = \left[\frac{R_{sample}}{R_{standard}} - 1 \right] * 1{,}000$$

We will be glad to take account of your preferred delta shift in your order.

The mass spectrometer, installed in a research aircraft, was calibrated using the $^{34}SO_2$ isotope



Know-how for practitioners.

For further questions on isotopes and isotope mixtures Westfalen's Specialty Gases experts are at your disposal at any time. Use our personal consultation!

We would also be delighted to send you previous publications in the "Speciality Gases Practice" range:

- Specialty Gases Practice (1) – Using Gas Mixtures: Handling, Connection, Special Cases.
- Specialty Gases Practice (2) – Gases in the Laboratory: Risk Factor Tube Material.
- Specialty Gases Practice (3) – Accredited Test and Calibration Laboratory: The Westfalen Specialty Gases Centre.

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