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SEMESTR-VI

CHEMISTRY (DSE - IV)

INDUSTRIAL CHEMICALS & ENVIROMENT-

1. INDUSTRIAL GASES & INORGANIC CHEMICALS

Industrial gases- Hydrogen & Helium

Cryogenic technologies also allow the liquefaction of natural gas, hydrogen and helium. In natural-gas processing, cryogenic technologies are used to remove nitrogen from natural gas in a Nitrogen Rejection Unit; a process that can also be used to produce helium from natural gas where natural gas fields contain sufficient helium to make this economic. The larger industrial gas companies have often invested in extensive patent libraries in all fields of their business, but particularly in cryogenics.

The universal emergence of atomic hydrogen first occurred during the recombination epoch (Big Bang). At standard temperature and pressure, hydrogen is a colorless, odorless, tasteless, non-toxic, nonmetallic, highly combustible diatomic gas with the molecular formula H_2. Since hydrogen readily forms covalent compounds with most nonmetallic elements, most of the hydrogen on Earth exists in molecular forms such as water or organic compounds. Hydrogen plays a particularly important role in acid–base reactions because most acid-base reactions involve the exchange of protons between soluble molecules. In ionic compounds, hydrogen can take the form of a negative charge (i.e., anion) when it is known as a hydride, or as a positively charged (i.e., cation) species denoted by the symbol H^+. The hydrogen cation is written as though composed of a bare proton, but in reality, hydrogen cations in ionic compounds are always more complex. As the only neutral atom for which the Schrödinger equation can be solved analytically, study of the energetics and bonding of the hydrogen atom has played a key role in the development of quantum mechanics.

Hydrogen is mainly from steam reforming natural gas, and less often from more energy-intensive methods such as the electrolysis of water.[10] Most hydrogen is used near the site of its production, the two largest uses being fossil fuel processing (e.g., hydrocracking) and ammonia production, mostly for the fertilizer market. Hydrogen is problematic in metallurgy because it can embrittle many metals, complicating the design of pipelines and storage tanks.[12]

Applications

Petrochemical industry

Large quantities of H_2 are used in the "upgrading" of fossil fuels. Key consumers of H_2 include hydrodealkylation, hydrodesulfurization, and hydrocracking. Many of these reactions can be classified as hydrogenolysis, i.e., the cleavage of bonds to carbon. Illustrative is the separation of sulfur from liquid fossil fuels:

$$R\text{-}S\text{-}R + 2\ H_2 \rightarrow H_2S + 2\ RH$$

Hydrogenation

Hydrogenation, the addition of H_2 to various substrates is conducted on a large scale. The hydrogenation of N2 to give ammonia by the Haber - Bosch process consumes a few percent of the energy budget in all of industry. The resulting ammonia is used to supply the majority of the protein consumed by mankind.[102] Hydrogenation is used to convert unsaturated fats and oils to saturated fats and oils. The major application is the production of margarine. Methanol is produced by hydrogenation of carbon dioxide. It is similarly the source of hydrogen in the manufacture of hydrochloric acid.H_2 is also used as a reducing agent for the conversion of some ores to the metals.

Coolant   Main article: Hydrogen-cooled turbo generator

Energy carrier

See also: Hydrogen economy, Hydrogen infrastructure, and Hydrogen fuel

Safety and precautions

Hydrogen poses a number of hazards to human safety, from potential detonations and fires when mixed with air to being an asphyxiant in its pure, oxygen-free form.[133] In addition, liquid hydrogen is a cryogen and presents dangers (such as frostbite) associated with very cold liquids. Hydrogen dissolves in many metals, and, in addition to leaking out, may have adverse effects on them, such as hydrogen embrittlement, leading to cracks and explosions. Hydrogen gas leaking into external air may spontaneously ignite. Moreover, hydrogen fire, while being extremely hot, is almost invisible, and thus can lead to accidental burns.

HELIUM:-

Natural abundance

Although it is rare on Earth, helium is the second most abundant element in the known Universe, constituting 23% of its baryonic mass. Only hydrogen is more abundant. The vast majority of helium was formed by Big Bang nucleosynthesis one to three minutes after the Big Bang. As such, measurements of its abundance contribute to cosmological models. In stars, it is formed by the nuclear fusion of hydrogen in proton-proton chain reactions and the CNO cycle, part of stellar nucleosynthesis.

In the Earth's atmosphere, the concentration of helium by volume is only 5.2 parts per million. The concentration is low and fairly constant despite the continuous production of new helium because most helium in the Earth's atmosphere escapes into space by several processes. In the Earth's heterosphere, a part of the upper atmosphere, helium and other lighter gases are the most abundant elements.

Production of Helium:-

For large-scale use, helium is extracted by fractional distillation from natural gas, which can contain as much as 7% helium. Since helium has a lower boiling point than any other element, low temperature and high pressure are used to liquefy nearly all the other gases (mostly nitrogen and methane). The resulting crude helium gas is purified by successive exposures to lowering temperatures, in which almost all of the remaining nitrogen and other gases are precipitated out of the gaseous mixture. Activated charcoal is used as a final purification step, usually resulting in 99.995% pure Grade-A helium. The principal impurity in Grade-A helium is neon. In a final production step, most of the helium that is produced is liquefied via a cryogenic process. This is necessary for applications requiring liquid helium and also allows helium suppliers to reduce the cost of long distance transportation, as the largest liquid helium containers have more than five times the capacity of the largest gaseous helium tube trailers.

Helium is commercially available in either liquid or gaseous form. As a liquid, it can be supplied in small insulated containers called dewars which hold as much as 1,000 liters of helium, or in large ISO containers which have nominal capacities as large as 42 m^3 (around 11,000 U.S. gallons). In gaseous form, small quantities of helium are supplied in high-pressure cylinders holding as much as 8 m^3 (approx. 282 standard cubic feet), while large quantities of high-pressure gas are supplied in tube trailers which have capacities of as much as 4,860 m^3

Uses

The use of helium reduces the distorting effects of temperature variations in the space between lenses in some telescopes, due to its extremely low index of refraction. This method is especially used in solar telescopes where a vacuum tight telescope tube would be too heavy.

Helium is a commonly used carrier gas for gas chromatography.

The age of rocks and minerals that contain uranium and thorium can be estimated by measuring the level of helium with a process known as helium dating.

Helium at low temperatures is used in cryogenics, and in certain cryogenics applications. As examples of applications, liquid helium is used to cool certain metals to the extremely low temperatures required for superconductivity, such as in superconducting magnets for magnetic resonance imaging. The Large Hadron Collider at CERN uses 96 metric tons of liquid helium to maintain the temperature at 1.9 kelvins

Hazards

Inhaling helium can be dangerous if done to excess, since helium is a simple asphyxiant and so displaces oxygen needed for normal respiration. Fatalities have been recorded, including a youth who suffocated in Vancouver in 2003 and two adults who suffocated in South Florida in 2006. In 1998, an Australian girl from Victoria fell unconscious and temporarily turned blue after inhaling the entire contents of a party balloon. Inhaling helium directly from pressurized cylinders or even balloon filling valves is extremely dangerous, as high flow rate and pressure can result in barotrauma, fatally rupturing lung tissue.

Applications

While balloons are perhaps the best known use of helium, they are a minor part of all helium use.[63] Helium is used for many purposes that require some of its unique properties, such as its low boiling point, low density, low solubility, high thermal conductivity, or inertness. Of the 2014 world helium total production of about 32 million kg (180 million standard cubic meters) helium per year, the largest use (about 32% of the total in 2014) is in cryogenic applications, most of which involves cooling the superconducting magnets in medical MRI scanners and NMR spectrometers.[140] other major uses were pressurizing and purging systems, welding, maintenance of controlled atmospheres, and leak detection. Other uses by category were relatively minor fractions.