THE ANZ HYDROGEN HANDBOOK VOL II

HYDROGEN CHEAT SHEET

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Hydrogen's future significance in energy lies in its versatile role as a clean energy carrier, helping enable decarbonisation across challenging sectors.

It will help provide versatile energy storage and will benefit from ongoing technological advancements to foster a sustainable and resilient energy landscape.

Hydrogen will play an important role in energy, fuel cells, transportation, industrial processes, and chemical production.

KEY VECTORS

HYDROGEN (H_2)

- Hydrogen is the lightest and simplest chemical element.
- It is commonly formed through natural gas reforming or water electrolysis.
- There are diverse applications including: use as a fuel in fuel cells for vehicles, as a reducing agent in industrial processes, and as a component in ammonia and other related vectors.

AMMONIA (NH_3)

- Ammonia is a compound made up of one nitrogen atom bonded to three hydrogen atoms. It is a colourless gas with a pungent smell.
- It is often formed through the Haber-Bosch process, where nitrogen gas (N_2) from the air reacts with hydrogen gas (H_2) under high pressure and temperature.
- It is widely used in agriculture as a fertilizer. It is also used in refrigeration systems, as a cleaning agent, and in the manufacturing of various chemicals.

SYNTHETIC METHANE (CH_4)

- Synthetic methane, also known as synthetic natural gas (SNG), is a human-made or synthetic version of methane gas, the primary component of natural gas.
- It is formed through a process called methanation, where carbon dioxide (CO_2) and hydrogen (H_2) react to produce methane. The hydrogen needed for this process can be obtained through electrolysis.
- It can be used as a sustainable energy source, injected into existing natural gas pipelines, used for heating, electricity generation, or as fuel for vehicles.

METHANOL (CH_3OH)

- Methanol is an alcohol that is commonly used as an industrial solvent and fuel.
- Methanol is typically produced through a chemical process called synthesis gas production, where carbon monoxide (CO) and hydrogen (H_2) react. This synthesis gas is then further processed to form methanol.
- Methanol has applications across: being used as a fuel, antifreeze, solvent, and in the production of chemicals and plastics. Additionally, it is used in other chemical derivatives and is being explored as a potential renewable fuel source.

KEY USES

- Fuel cells: Hydrogen is a primary fuel for fuel cells, with applications in vehicles, backup power systems, and stationary power generation.
- Transportation: Hydrogen is used as a clean fuel for various modes of transportation, including hydrogen-powered vehicles such as cars, buses, trucks, and trains, offering low or zero emission mobility.
- Industrial processes: In industries such as refining, metal production, and chemical manufacturing, hydrogen serves as a crucial reducing agent, enabling processes like desulfurisation and ammonia production.
- Energy storage: Hydrogen acts as a storage medium for excess renewable energy. Excess renewable energy not used by the grid can be used to power electrolysis to produce hydrogen, which can be stored and used later when demand is high.
- Chemical production: Hydrogen is a key element in the production of various chemicals including ammonia for fertilizers, methanol, and in petroleum refining processes.

CONVERSION FACTORS

BASIC CONVERSION FACTORS

Weight Conversions

	Metric tonne	Kilogram	Short ton
Metric tonne	1	1000	1.1023
Kilogram	0.001	1	0.0011023
Short ton	0.907185	907.185	1

Temperature Conversion

	˚C	˚F
˚C	0	32
˚F	-17.7778	0

Pressure Conversion

	Bar	Pascal (P)	megaPascal (MPa)
Bar	1	100000	0.1
Pascal	0.00001	1	0.000001
megaPascal (MPa)	10	1000000	1

Volume/Energy Conversions

	Kilowatt hour (kWh)	Joule (J)	Megajoule (MJ)
Kilowatt hour (kWh)	1	3,600,000	3.6
Joule (J)	2.77778×10^{-7}	1	1×10^{-6}
Megajoules (MJ)	0.277778	1000000	1

	Weight		Gas		Liquid	
	pounds (lb)	kilograms (kg)	cubic feet (scf)	cu meters (Nm^3)	gallons (gal)	litres (l)
1 pound	1.0	0.4536	191.26	5.4159	1.6925	6.407
1 kilogram	2.2046	1.0	1 421.66	11.940	3.37313	14.125
1 scf gas	0.005309	0.002408	1.0	0.02679	0.008985	0.03401
1 Nm^3 gas	0.1982	0.08989	37.327	1.0	0.3354	1.2697
1 gallon liquid	0.5908	0.2680	113.0	2.9815	1.0	3.7855
1 litre liquid	0.1561	0.07080	29.852	0.8453	0.2642	1.0

Scf (standard cubic foot) gas measured at 1 atmosphere and 60°F.
Nm^3 (normal cubic meter) gas measured at 1 atmosphere and 0°C.
Liquid measured at 1 atmosphere and boiling temperature.

	Kilowatt (kW)	Megawatt (MW)
1 Kilowatt (kW)	1	0.001
1 Megawatt (MW)	1000	1

THERMODYNAMIC PROPERTIES OF HYDROGEN[265]

Parameter	Value
Hydrogen HHV (ΔH)	-286 kJ/mol
Hydrogen LHV (ΔH)	-242 kJ/mol
Energy content of 1 kg hydrogen	141.9 MJ (HHV) = 0.1419 GJ = 39.4 kWh
	120.1MJ (LHV) = 0.1201 GJ = 33.3 kWh
Energy content of 1 N-m^3 hydrogen	12.7 MJ (HHV) = 0.0127 GJ
Energy content of 1 gallon of gasoline	121.3 MJ (LHV) = 0.1213 GJ

ΔH = Enthalpy (total heat content of the system, negative enthalpy indicates ectothermic reaction)

kJ = Kilojoule (=1000 joules)

HHV = Higher Heating Level (the upper limit of available thermal energy produced by the complete combustion of hydrogen)

LHV = Lower Heating Level (amount of heat released by combusting a specified quantity and returning the temperature of the combustion products to 150˚C)

REFERENCES

265 National Research Council And National Academy Of Engineering Of The National Academies. (2004). *Appendix H: Useful conversions and thermodynamic properties | The hydrogen economy: Opportunities, costs, barriers, and R&D needs | The National Academies Press*. https://nap.nationalacademies.org/read/10922/chapter/21

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