Increasing atmospheric CO$_2$ concentration will continue to be a risk if we continue to use fossil fuels as our main energy source. Hydrogen is the ideal low carbon fuel/energy vector to replace fossil fuels facilitating the energy transition, without further increasing gas atmospheric CO$_2$ concentrations. Thermodynamic characterisation of hydrogen and hydrogen mixed gases is important to solve the challenging production and storage issues in a hydrogen-based economy. Thermodynamic characterisation is vital to design more efficient and more economic production and storage processes, and must be undertaken as a crucial first step for wide application of hydrogen-based fuels and their storage. Here we applied a highly accurate equation of state, namely, GERG-2008, to predict various thermodynamic properties (e.g. phase behaviour, density, viscosity, compressibility, and heat capacity) of hydrogen when mixed with other gases including: CO$_2$, CH$_4$, N$_2$, and natural gas. Given the important influence of other constituents in the hydrogen gas stream on the thermodynamic properties of hydrogen, such thermodynamic data could be used for efficient design, development, and deployment of innovative hydrogen production, transport, blending and storage techniques. Understanding the thermodynamic characterisation of hydrogen and hydrogen mixed gasses is particularly important for geological hydrogen storage, where the thermodynamic properties of the injected gas in equilibrium with existing fluids in the storage reservoir is required to estimate the storage capacity. The data is provided over wide range of pressure, temperature, and molar combination representing the range of fuel blending, applications and storage conditions for hydrogen.