Can Hydrogen separate from a Hydrogen/Nitrogen mixture?

Hydrogen has the lowest density of all gases. If pure Hydrogen (100%) is released inside a building the gas cloud will rise towards the ceiling because of its high buoyancy (density 0.09 g/liter compared to air which is 1.3 g/liter). However, since Hydrogen dissipates much quicker than any other gas there will be much less accumulation at the ceiling than most people would expect. The Hydrogen gas is rather quickly diluted with air and looses its buoyancy.

The situation is very different when diluted Hydrogen (e.g. 5% Hydrogen in Nitrogen) is being used. The Hydrogen/Nitrogen mix (containing 95% Nitrogen) already has a density very similar to air and therefore hardly any buoyancy. The dissipation factor is overwhelmingly dominant and the gas follows the air movements that are due to temperature variations and ventilation.

Air contains 80% Nitrogen. When Hydrogen molecules in the gas mix spread they move from being diluted by Nitrogen in the cylinder to being diluted by Nitrogen in air. There is no driving force making them concentrate in any of these media. As a matter of fact, the Second Law of Thermodynamics states that such a process is impossible at all times. Therefore, if the Hydrogen concentration in the cylinder is 5%, the concentration will quickly reduce when let free, and not increase. If the gases in the mixture would separate they would have done that in the cylinder already.

Gas suppliers sell mixtures of 5% Hydrogen in Nitrogen, confident that the Hydrogen gas does not collect at the top of the cylinder. If it did, the customer would get pure Hydrogen when he opens the cylinder and safety regulations would not allow them to sell such cylinders classified as non-flammable gas.

Furthermore, if spontaneous gas separation would take place we would all be suffocated by carbon dioxide in the atmosphere gathering at ground level. One actually needs to go several kilometers up in the atmosphere to detect any variation in oxygen/Nitrogen/carbon dioxide composition. The difficulty to breathe at high altitudes is due to low pressure, not to different air composition.

The gases stays mixed because they are perfectly soluble in each other. Also soluble liquids stay mixed if they are perfectly soluble. Two well know substances that are soluble in each other and have different densities are alcohol and water. Being careful one can arrange pure ethanol to float on top of water for a while, but if you mix them, the two components will stay mixed. When buying a bottle of liquor you don’t expect the first drink you pore from the bottle to be stronger than the following ones.

Then, what about White Spirit and water, why do they separate? The simple answer is that they are not soluble in each other. Therefore they separate spontaneously and the lightest component floats on top of the heavier one.