

Citation:

H. Kamerlingh Onnes, Contributions to the knowledge of the psi-surface of Van der Waals. XI. A gas that sinks in a liquid, in:

KNAW, Proceedings, 9 I, 1906, Amsterdam, 1906, pp. 459-460

Physics. — “*Contribution to the knowledge of the ψ -surface of VAN DER WAALS. XI. A gas that sinks in a liquid.*” By Prof. H. KAMERLINGH ONNES. Communication N^o. 96 from the Physical Laboratory of Leiden.

If we have an ideal gas and an incompressible liquid without vapour tension, in which the gas does not dissolve, the gas will gather above the liquid under the action of gravity, if the pressure is sufficiently low, whereas the compressed gas will sink in the liquid if the pressure is made high enough.

I have observed a phenomenon approaching to this fictitious case in an experiment which roughly came to this, that helium gas was compressed more and more above liquid hydrogen till it sank in the liquid hydrogen. Roughly, for so simple a case as was premised is not to be realized. Every experiment in which a gas is compressed above a liquid, is practically an application of the theory of binary mixtures of VAN DER WAALS. In such an experiment the compressibility of the liquid phase and the solubility of gas and liquid inter se may not be neglected, as generally the pressure will even have to be increased considerably before the density of the gas-phase becomes comparable with that of the liquid phase.

If the theory of VAN DER WAALS is applied to suchlike experiments, the question lies at hand whether in the neighbourhood of the plait-point phenomena where gas and liquid approach each other so closely that of the ordinary gas and liquid state they have retained nothing but the name, perhaps on account of a higher proportion of the substance with greater molecular weight¹⁾ the phase, which must be called the gas phase, may become specifically heavier than the phase, which must be called the liquid phase. On closer investigation it appears however, to be due to relations between the physical properties and the chemical constitution (so also the molecular weight) of substances, that a liquid phase floating on a gas phase has not been observed even in this favourable region.

I was the more struck with an irregularity which I came across when experimenting with helium and hydrogen in a closed metal vessel, as I thought that I could explain it by the above mentioned not yet observed phenomenon, and so the conviction took hold of me, that at -253° and at a pressure of 60 atmospheres the gaslike phase which chiefly consists of helium, sinks in the liquid phase which chiefly consists of hydrogen.

¹⁾ The limiting case is that in the ψ -surface construed with the unity of weight the projection of the nodal chord on the xv -plane runs parallel to the line $v = 0$.

In order to ascertain myself of this I compressed by means of the mercury compressor described in Communication N^o. 54 a mixture of about one part of helium and 6 parts of hydrogen in a glass tube, which had a capillary inflow tube at the top, and a capillary outlet tube at the bottom, and which was merged in liquid hydrogen.

Up to 49 atmospheres the liquid hydrogen was seen to deposit from the gas mixture, bounded by a distinct hollow meniscus against the helium. At 49 atmospheres the helium, or properly speaking the gas phase consisting chiefly of helium, went down just as water through oil, and remained on the bottom as a large drop. With further compression to 60 atmospheres and decrease of pressure to 32 atmospheres the volume of the bubble appeared to follow the change of the pressure as that of a gas. At 32 atmospheres the bubble rose again. By changing the pressure the bubble was made to rise and descend at pleasure.

The closer investigation of these phenomena in connection with the isotherms of helium and the ψ -surfaces of H₂ and He is an extensive work, so that in anticipation of the results which most likely will be definitely drawn up only much later, I feel justified in confining myself to this sketchy communication.

One remark may be added now. It appears that the b of helium must be small, from which follows again that a must have an exceedingly small value, because the critical temperature, if it exists, must lie very low. In this direction points also a single determination of the plaitpoint of a mixture of helium and hydrogen which I have already made. Whether a has really a positive value, whether it is zero, or whether (what is also conceivable) a is negative, will have to be decided by the determination of the isotherms of helium.

(December 21, 1906).