

A Gas That Sinks in a Liquid - Kamerlingh Onnes' First Helium Experiment

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When a sufficient quantity of purified helium became available to Kamerlingh Onnes in 1905, his first priority was estimating the critical temperature of helium, so that the dimensions of the planned liquefier and the quantities of coolants needed in the cascade could be established. So he initiated the tedious work of measuring the pressure-density relation of helium gas along isotherms down to cryogenic temperatures. But November 1906, he decided to do something more interesting. He fed a mixture of helium and hydrogen gas into a glass tube immersed in liquid hydrogen. The mixture formed two phases, which persisted even when the pressure was raised to 60 atmospheres. At the higher pressures, however, he observed how the vapor phase became denser than the liquid phase and sank to the bottom: the barotropic effect. It was not difficult for him to come up with a qualitative explanation. A quantitative model, however, might give him a chance to estimate the critical temperature of helium. His assistant Keesom helped him with this task, using Van der Waals' theory of mixtures of 1890. But they overlooked Van Laar's 1905 paper on types of mixture phase diagrams, which was based on the same theory, and agreed with mixture experiments by Kuenen, some of which performed in Leiden as early as 1892. The work of Kamerlingh Onnes and Keesom led to spirited interactions with both Van der Waals and Van Laar. Unfortunately, the resulting model could not provide a reliable estimate of the critical temperature. This had to wait till late 1907, when the work on the isothermal grid of helium neared completion.

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