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Properties of Liquid Helium

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Abstract:

This article is about unusual properties or behaviour of liquid helium and its uses.

The normal boiling point of helium is 4.22 K. Keesom in 1932 cooled it to 0.71 K by making it boil under reduced pressure of 0.0036 mm of mercury, but could not freeze.

Liquid helium has a number of unusual physical properties. These are:

1. Its density is maximum at 2.2 K, being 0.1462 g/c.c. . With the decrease of temperature, the density decreases and tends to be constant below 1.5 K.
2. It is now established that liquid helium undergoes a transition at a temperature of 2.186 K. This temperature is known as the λ-point.
3. The liquid helium is called Helium I above the λ-point and is termed Helium II below it.

Interestingly, the two forms of liquid He are strikingly different in their physical properties. For instance, He II has an extraordinarily high thermal conductivity, unusually low viscosity. The liquid creeps along a surface rapidly so much so that a flask partly lowered into the liquid will gain or loose He II as if the flask was porous. He atoms move practically unhindered through He II — a process analogous to superconductivity where electrons move through metals practically unhindered. Below 1 K, He II appears to lose its abnormal properties. Between 1 to 2 K, it resembles no other liquid, gas or solid.

Uses of Liquid Helium:

1. **Testing the purity of metal:** This is done by observing the residual resistance at liquid helium temperature. In pure metals, the residual resistance vanishes at very low temperatures, even if they are not superconductors.
2. **Computers:** superconducting computers are fast in action and compact in size.
3. **Attainment of High Vacuum:** A pressure of as low as 10^{-12} mm of HG can be reached by cooling the vessel in liquid helium.
4. **Cooling of Powerful Electromagnets:** Ultra-high cooling by liquid helium reduces the resistance of the coils and thus enables them to carry larger currents

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apart from the removing away the heat developed.

5. **Superconducting Bolometers:** Using liquid helium temperature extremely sensitive superconducting bolometers may be developed which can measure the heat energy coming from the stars.

Helium can be solidified by increasing the pressure on the liquid. At 4.2 K the required pressure is 250 atmos. By increasing the pressure, the solid may be kept in equilibrium with the vapour even above the critical temperature, namely 5.2 K. Thus, although a substance cannot exist in the liquid state above its critical temperature, it may exist in the solid-state above it if the applied pressure is sufficiently high.

Helium does not have a triple point in the sense of coexistence of solid, liquid and vapour phases at some temperature and pressure.

Reference:

Thermal physics —A.B. Gupta , H.P. Roy.