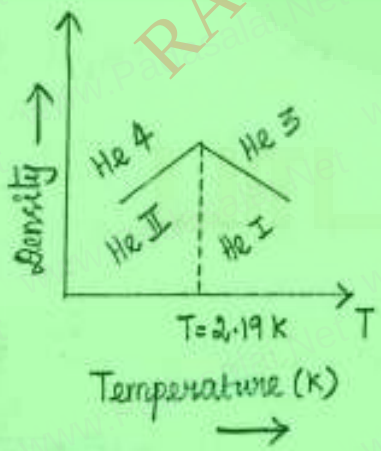
Properties of liquid Helium

⇒ Helium is a remarkable substance, it was first discovered in the Sun then on Earth

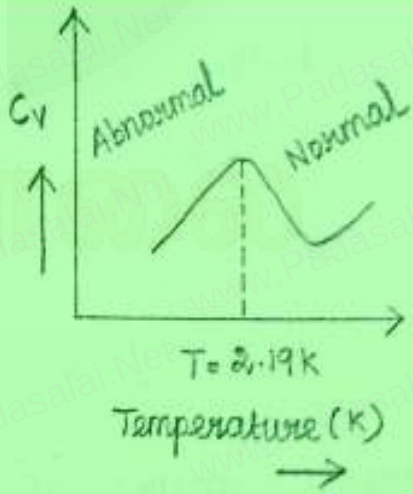
⇒ Helium was first gas to be liquefied on account of having the lowest critical temperature ($T_c = -5.25\,K$)

⇒ It is colourless, transparent, very volatile liquid and has the lowest boiling point of $4.2\,K$ at pressure of 1 atmosphere.

⇒ Kamerlingth Onnes found a specific discontinuity in the density of helium at $2.19\,K$



Density Vs Temp.



Specific Heat Vs Temp.

⇒ The density of liquid He increases as the temperature decreases from 4K to 2.19 K

⇒ The density becomes maximum (146.2 Kg/m^3) at 2.19 K

⇒ The specific heat of liquid Helium increase upto 2.19 K

⇒ Beyond 2.19 K, The specific heat first increases and then decreases.

⇒ The point 2.19 K is also known as Lambda Point.

⇒ The properties of liquid Helium above and below λ point quite different.

⇒ Liquid Helium above 2.19 K is called Helium I and it behave in a normal manner.

⇒ Liquid Helium below 2.19 K is called Helium II, because of its abnormal properties.

⇒ No heat is evolved (or) absorbed during the transition from Helium I to Helium II and vice versa.

⇒ Entropy of Helium I is practically same as that of Helium II.

⇒ The density of both types of liquid is about the same.

⇒ Viscosity of Helium I decreases with decreasing temperature

⇒ Viscosity of liquid Helium II is almost zero and it can flow rapidly through narrow capillary tube.

⇒ Liquid Helium I is a normal liquid while liquid Helium II presents very anamalous behaviour.

⇒ The thermal conductivity of He II is abnormally high.

⇒ There are two isotopes of He of mass three and four designated He^3 & He^4 at the temperature of the order 1K (or) 2K

⇒ He^4 contains 2 protons, 2 neutrons, 2 electrons Total spin is zero & zero entropy and hence obey Bose-Einstein Statistics

⇒ The isotopes of He^3 has half integral spin and obey Fermi-Dirac Statistics.

⇒ The liquid He^4 shows a dramatic changes in properties at temperature 2.19K (or) 2.18 K called T_λ.

⇒ The viscosity of liquid He^4 tends to zero. The phenomenon is called Super fluidity

⇒ This separates the liquid He^4 into two phases called He I & He II

⇒ The transition from He I to He II is not accompained by a latent heat

⇒ The shape of the specific heat curve near the transition point has the shape of letter lambda. It is a phase transition of seond kind.

⇒ The thermal conductivity of He II has an abnormally high value and it is many times more than that of Cu & Ag

⇒ The depth of the potential well is of the order of 10K for the Lennard - Jones potential

⇒ The average interparticle distance is of the order of 4.44 Å

⇒ Liquid He-II is a mixture of two fluids

* The normal fluid
* The super fluid

⇒ Helium is only substance which remains liquid under ordinary pressure at absolute temperature.

⇒ All other freezer to solid state if suffiiently cooled.

⇒ Solidification of Helium takes place under external pressure exceeding 25 atmospheres

Some peculiar properties of He-II

1. Super fluidity

2. High heat conductivity

   He-II is nearly 13.5×10^6 times more conductivity than liquid He-I

3. High electrical conductivity (or) Superconductivity

4. Formation of rolling film

   Liquid He-II form a thin film.

Note:

1. Normal boiling point of He is 4.2 K