PHYS-E055102, Low Temperature Physics, Exercise 4 DL 05.10.2022

1. Derive an expression for the Kapitza resistance between a solid and a liquid using the acoustic mismatch model. (We're looking for a proper derivation. Just presenting the lecture notes again is not enough.)

   Hint: As in the lecture notes, start with Snell's law.

2. One cubic centimeter of non-pressurized ^{3}He liquid is cooled in a cube-shaped cell. Determine the time constant with which the liquid cools at 10 mK. Use the values $c_3 = 23\,T\,\mathrm{J/mol\ K^2}$ for the heat capacity of ^{3}He and $R_K = 0.04\,A^{-1}T^{-3}\,\mathrm{m^2K^4/W}$ for the contact resistance.

3. How thick layer of silver powder should be sintered on the walls of the copper cell in the previous problem to achieve a ^{3}He cooling time constant of one minute at 10 mK? Use the value of contact resistance given in the previous problem and assume a filling ratio of 0.5 for the sinter and a surface area of $2\,\mathrm{m^2/g}$.

4. A helium chamber has a sintered silver heat exchanger with a total surface area of $50\,\mathrm{m^2}$. Estimate the lowest attainable temperature

   a) in pure liquid ^{3}He

   b) in liquid ^{3}He - ^{4}He mixture

   when the heat leak into the sample is 0.1 nW. At a temperature below 10 mK, one can use a value of $1000\,A^{-1}T^{-1}\,\mathrm{m^2K^2/W}$ for the Kapitza resistance of pure ^{3}He and $16\,A^{-1}T^{-2}\,\mathrm{m^2K^3/W}$ for the mixture.

5. Most materials contract when their temperature is decreased. Explain why metals typically contract less than plastics and dielectrics. Why some materials can have a negative coefficient of contraction, i.e. they expand while cooled down?