Tfy-3.4801	Low temperature physics: Basics of cryoengineering	Examination, 28.01.2014

1. Give short answers to the following questions:
   a) What is the purpose of the orifice in pulse tube refrigerators?
   b) How can you estimate heat conduction through a metal wire from room temperature to 4 K?
   c) Give three different superconducting elements and examples for their use in cryogenics.
   d) Carbon exists as several allotropes. Give a few examples and discuss their specific heat and thermal conductivity at low temperatures.
   e) How do spin-spin interactions affect magnetic cooling and thermometry?

2. Following table gives measured values of heat capacity of some metal. Make a representative plot of these data and explain the general behavior. Are there indications of superconductivity or magnetism in this data? Extrapolate the given values in a sensible way to $T = 20$ K, and estimate the amount of heat released when one mole of that material is cooled down from there to 1 K.

T [K]	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
C [mJ/(mol K)]	1.50	1.75	2.05	2.35	2.65	3.00	3.40	3.80	4.25	4.80	5.30	5.90

3. Helium isotopes have rich phase diagrams at low temperatures with several different phases and phase transitions. How can these be exploited for the purpose of refrigeration? Describe as many different ways as you can, give the range of achievable temperatures and some argument about the cooling power of different methods.

4. A specimen was attached to a refrigerator by a thermal link made out of silver. The cross sectional area and length of the link were $A = 15$ mm^2 and $l = 100$ mm, respectively. Silver has electrical resistivity $\rho = 16$ nΩm at room temperature, and the used material had $RRR = 1500$. The measurement produced heating of 14 nW in the sample. What was the temperature of the specimen during measurements, when the refrigerator was at 100 μK or at 1 mK? Contact resistances may be ignored. The Lorentz number is $L_o = 24.4$ nWΩ/K^2.