

Course code	F7045T (F7006T)
Examination date	2019-06-07
Time	9.00 - 14.00 (5 hours)

Examination in: FASTA TILLSTÅNDETS FYSIK / SOLID STATE PHYSICS

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Allowed aids: Fysika(lia), Physics Handbook, Beta, calculator, COLLECTION OF FORMULAE for Solid state physics and COLLECTION OF FORMULAE for Quantum Physics.

Define notations and motivate assumptions and approximations. Present the solutions so that they are easy to follow.

Total number of problems: 5. Maximum number of point is 15 p. 7.5 points are required to pass the examination. Grades 3: 7.5, 4: 9.5, 5: 12.0

1. Heat capacity

The figure 1 shows the temperature dependence of the heat capacity C_v for Potassium (Kalium).

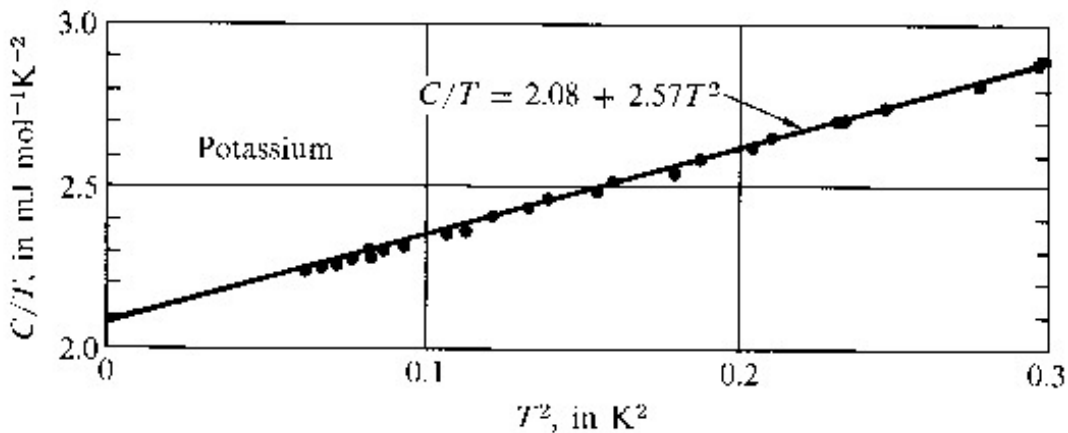


Figure 1: The specific heat of Potassium at low temperatures. The figure shows C_v/T (in mJ/(mole K²)) as a function of T^2 .

- What are the theories that explain a plot of C_v/T as a function of T^2 is linear.
- Use the data from the figure and crystal data to determine the Debye temperature θ_D .
- Use the data from the figure and crystal data to determine the effective mass of the electrons expressed in terms of the free electron mass m_0 . The Fermi energy is given by $E_F = k_B T_F$.

(3p)

TURN PAGE!

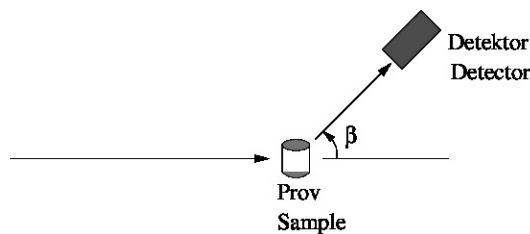


Figure 2: Principal sketch of the experiment showing the angle β

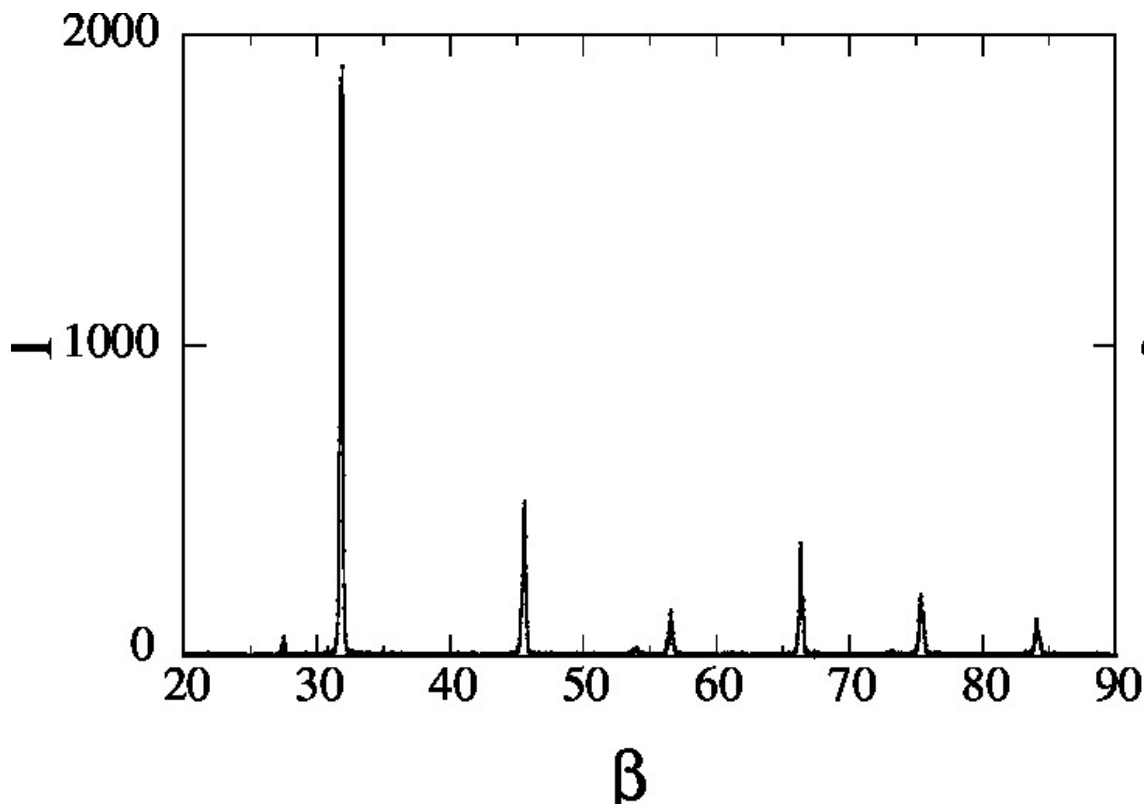


Figure 3: Bragg peaks (I for intensity) for a sample of unknown structure as a function of the angle β . **NB** There is a small peak for β between 25° and 30° .

2. Bragg scattering.

The diffraction pattern of a polycrystalline di atomic ionic powder is shown in figure (3). The X-rays used is the $K_{\alpha 1}$ line from copper (Cu). The angle β (see figure (2)) can be controlled between 0° and 90° . The outcome of the experiment is presented in the figure (3), where the intensity (I) of the deflected beam is presented as a function of β .

From the data in the figure determine the structure (sc, fcc, bcc or diamond) of the sample.

(3p)

3. Reciprocal space.

(a) For potassium (kalium) calculate the shortest distance in reciprocal space from the origin to the surface of the Brillouin zone.

(b) Is the Fermi sphere larger or smaller than the Brillouin zone and by how much?

(3p)

4. Electronbands

The electron energy near the top of the valence band in a semiconductor is given by $\epsilon = -10^{-37}k^2$ J, where \mathbf{k} is the wavevector. An electron is removed from the state $\mathbf{k} = 10^9\hat{\mathbf{k}}_x \text{ m}^{-1}$, where $\hat{\mathbf{k}}_x$ is a unit vector along the x axis. Calculate for the resulting hole:
(Let $\hbar = 10^{-34}$ Js)

(a) The effective mass.

(b) The Energy.

(c) The momentum.

(d) The velocity.

Each answer must include sign (or direction).

(3p)

5. Bandgap

The electrical resistance R of a semi conductor has been measured as a function of temperature T . The result is presented in the adjacent table. From the data given calculate the band gap.

T ($^{\circ}\text{C}$)	22.0	48.0	72.0	97.0	127
R (Ω)	182	92.0	53.0	32.0	17.2

(3p)

Good Luck !