LULEÅ UNIVERSITY OF TECHNOLOGY
Applied Physics

Course code	**F7006T**
Examination date	2014-12-19
Time	9.00 - 14.00 (5 hours)

Examination in: FASTA TILLSTÅNDETS FYSIK / SOLID STATE PHYSICS
Total number of problems: 5
Teacher on duty: Hans Weber Tel: (49)2088, Room E304
Examiner: Hans Weber Tel: (49)2088, Room E304

Allowed aids: Fysikalia, 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. 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

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1. **Mixed questions.**

   (a) Quarts glass is transparent to UV–light of the wave length $\lambda = 1700$ Å, whereas ordinary window glass is not. What can one deduce from this about the band gap of the two materials?

   (b) Based on simple arguments (no calculations) why can a material with two valence electrons be either an insulator or a poor conductor.

   (c) What is the principal difference between the phonon dispersion relation for Sodium and Germanium, draw a simple figure.
   (For a single direction only)

   (d) Can ordinary visible light be used to analyse the structure of crystals? Motivate !

   (3p)

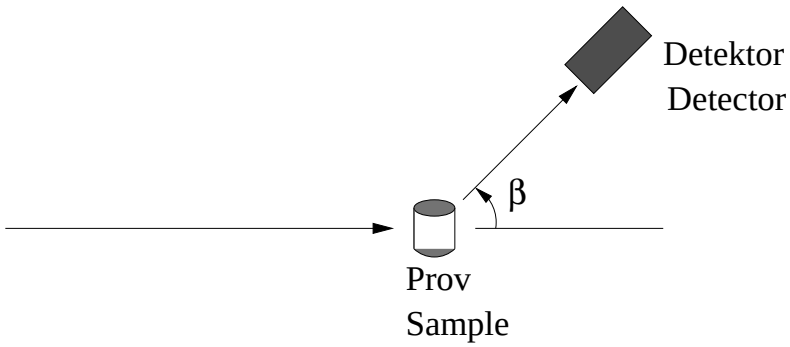
2. **Bragg scattering.**

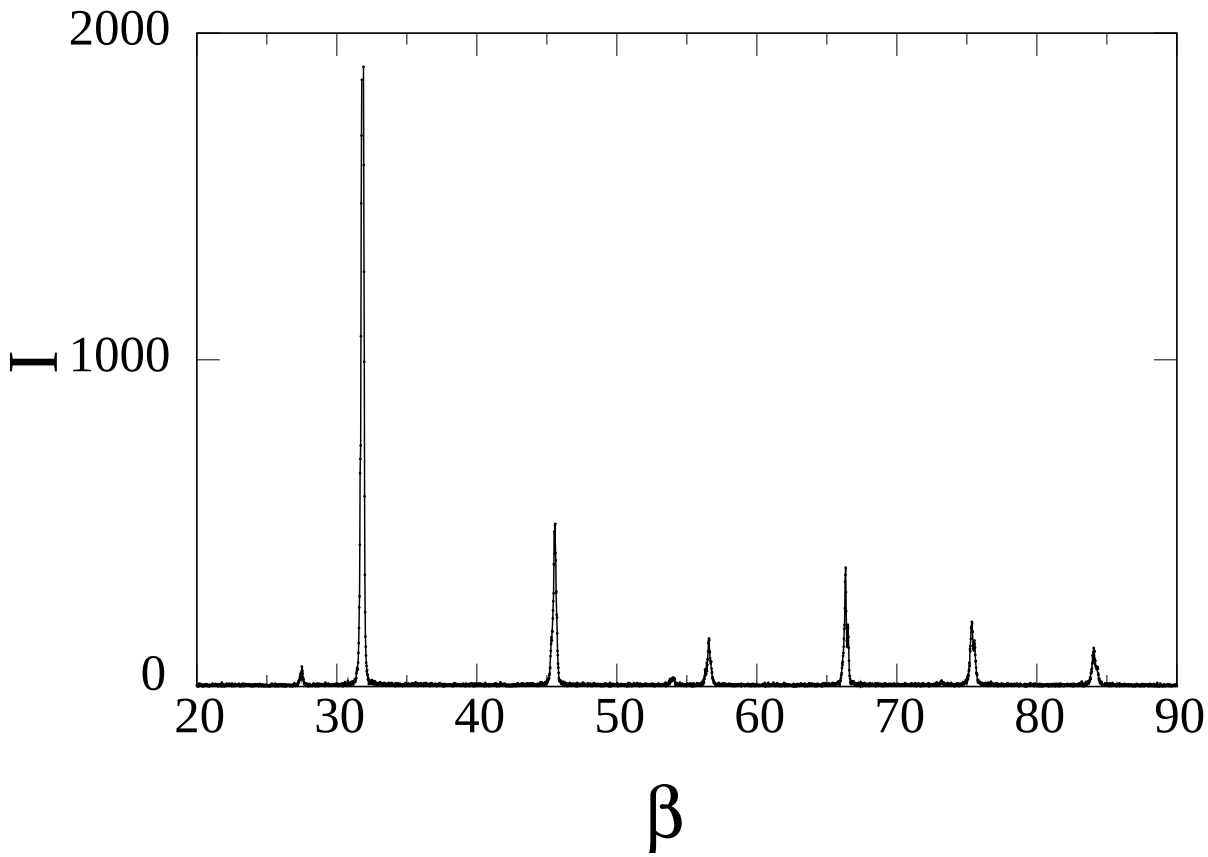
   The diffraction pattern of a polycrystalline mono atomic powder is shown in the figure below (next page). The X-rays used is the $K_{\alpha 1}$ line from copper (Cu). The angle β can be controlled between 0° and 90°. The outcome of the experiment is presented in the figure below, where the intensity (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)

TURN PAGE!


Detektor
Detector
β
Prov
Sample


2000
1000
0
I
20
30
40
50
60
70
80
90
β

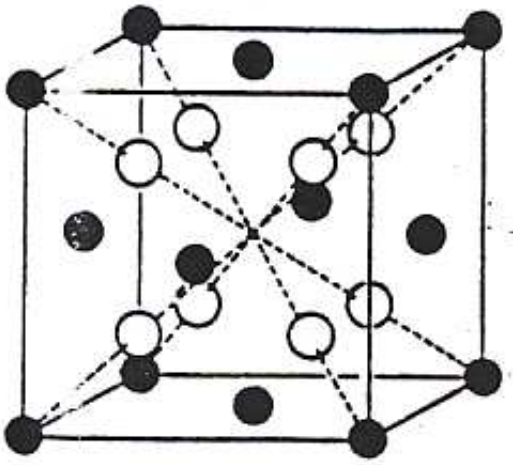
3. **Reciprocal space.**

(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. **Crystal structure.**



In the figure the crystal structure of Calcium fluoride CaF_2 (a = 5.46 Å) is shown.

(a) Determine the Bravais lattice of the structure and also the primitive translational vectors.

(b) Which atoms does the primitive cells contain? Which does the conventional cubic cell contain? Both position and kind of atom.

(c) Determine the three smallest Bragg scattering angels one can find doing and X-ray examination of a powder sample of CaF_2. The X-ray consists primarily of the $K_{\alpha 1}$ line from Copper.

(d) What would change if one instead used the $K_{\alpha 1}$ from Aluminum ?

(3p)

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5. **Heat capacity.**

The heat capacity C of Zn has been measured at low temperatures with the following result.

T (K)	1	2	3	4	6
C (J/K/mole)	0.72	1.83	3.80	7.19	18.9

Can you from these results calculate the heat capacity C for Zn at the following temperatures T = 10 K and T = 500 K?

If no motivate and if yes calculate C for the temperature in question.

(3p)

Good Luck !