

LULEÅ UNIVERSITY OF TECHNOLOGY

Applied Physics

Course code	<b>F7045T / F7006T (old)</b>
Examination date	2016-05-31
Time	9.00 - 14.00 (5 hours)

Examination in: FASTA TILLSTÅNDETS FYSIK / SOLID STATE PHYSICS

Total number of problems: 5

Teacher on duty: Nils Almqvist

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Examiner: Hans Weber

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Allowed aids: Fysikalia, Physics Handbook, Beta, calculator, COLLECTION OF FORMULAE for Solid state physics and COLLECTION OF FORMULAE for Quantum Physics.

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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. Heat capacity

Sodium metal displays free-electron-like behaviour. The thermal effective electron mass is equal to the electron mass and the Debye temperature is 160 K. What fraction of the total heat capacity at 300 K is contributed by the electrons. (3p)

### 2. Crystal structure

Aluminum, Chrome and Germanium are chemical elements with different crystal structures.

- How many atoms does the primitive unit cell contain in these elements?
- How many atoms does the conventional unit cell contain in these elements?
- Calculate the nearest and next nearest neighbour distance, in Ångström, for Germanium.

(3p)

TURN PAGE!

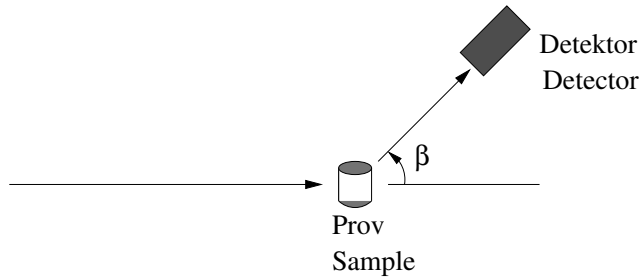


Figure 1: Principal drawing of the scattering setup

### 3. Semi conductor

The relative dielectric constant for reflection of Indium Antimonide (InSb) is  $\epsilon_r = 17$ . The effective mass of the electrons is  $m_e = 0.014m_0$ . Calculate:

- The donor ionisation energy.
- Estimate the radius of the electronic ground state orbit around a donor.
- At approximately how large concentration of donors will the ground state orbits start to overlap.
- What happens to the ground state of the donors if the concentration exceeds the result calculated in c). (3p)

### 4. 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
$R$ ( $\Omega$ )	182	92.0	53.0	32.0	17.2

(3p)

### 5. X-ray diffraction

Below you find data from a measurement of the x-ray diffraction pattern from a powder sample. The table shows the angles  $\beta$  where the diffraction peaks are found. Identify the cubic crystal structure. In Figure 1 the setup is shown.

$\beta$	30.3 $^{\circ}$	43.4 $^{\circ}$	53.9 $^{\circ}$	63.1 $^{\circ}$	71.6 $^{\circ}$	79.7 $^{\circ}$	87.6 $^{\circ}$
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(3p)

Good Luck !