LULEÅ UNIVERSITY OF TECHNOLOGY
Applied Physics

Course code	**F7045T**
Examination date	2018-10-26
Time	9.00 - 14.00 (5 hours)

Examination in: FASTA TILLSTÅNDETS FYSIK / SOLID STATE PHYSICS
Total number of problems: 5
Teacher on duty: Stephane Francois Tel: (49)2083, Room E159
Examiner: Hans Weber Tel: (49)2088, Room E163

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. 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. **Crystal structure and the reciprocal lattice**

   Three two-dimensional structures (A, B and C) are shown in Figure 1 (you may assume that in each case the pattern is repeated to in- finity).

   (a) For each structure write down a set of primitive lattice vectors, and briefly describe the primitive basis.

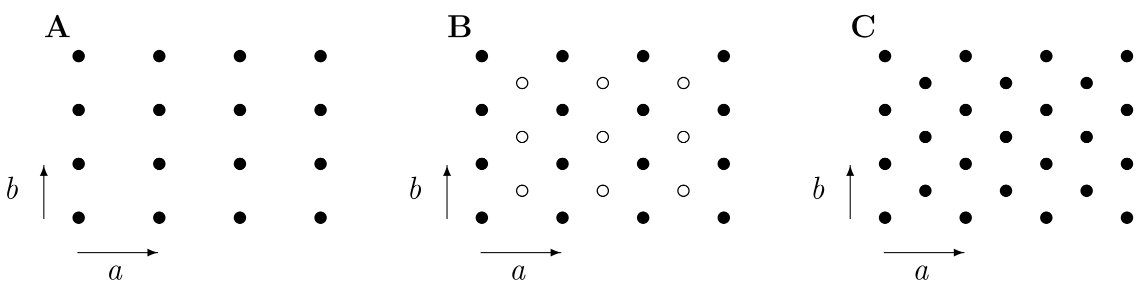

Figure 1: Three structures A, B and C. The markings • and ∘ represent different kinds of atoms.

   (b) Write down the reciprocal lattice vectors for structure A.

   (c) For structure A show that Bragg reflection can occur when $k - k' = n(2\pi/a)\hat{\imath} + m(2\pi/b)\hat{\jmath}$, where n and m are integers. The wavevectors of the incoming and outgoing beams are k and k'. (3p)

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2. **Bragg scattering**

Silicon (Si) and Galliumarsenid (GaAs) both have the same primitive lattice structure, fcc, with the following basises:

Si	(000),	$(\frac{1}{4}\frac{1}{4}\frac{1}{4})$
GaAs	Ga (000),	As $(\frac{1}{4}\frac{1}{4}\frac{1}{4})$

Determine the the Miller indexies for the first four allowed Bragg reflections with the smallest difraction angles (glansvinkel). The atomic formfactors are not equal for any of the different atoms.

(3p)

3. **The specific heat of Gold**

A measurement of the heat capacity C_v is performed. The results are given in the table below:

T (K)	1.6	2.0	2.4	2.8	3.2	3.6
C_v (J /kmol K)	4.18	6.88	10.7	15.9	23.0	31.8

Use these experimental results to determine the debye temperature Θ_D for Gold. (3p)

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4. **Semiconductor p–doped**

A thin layer of p-doped Silicon is irradiated by light. We measure the intensity of the transmitted light and we observe a strong absorption of the light at a wavelength of $\lambda = 59.1\mu$m.

(a) Make a figure and calculate the energy it takes to ionise the acceptor level.

(b) Can this experiment be performed at room temperature? If not, what temperature would be needed?

(c) Quarts is transparent to ultra violet light of a wavelength $\lambda = 1700$Å, but ordinary window glass is not. What does this tell us about the band gap of these two materials?

(3p)

5. **Semiconductor conductivity**

The electrical conductivity of semiconductors can be changed if impurities are introduced in the crystal. Find out how the electrical conductivity of silicon is changed if we introduce a small amount of antimony (Sb) in the crystal. The silicon crystal is doped in such a way that there is one Sb atom per 106 Si atoms. Is it true that the conductivity at 300 K of the doped silicon is 1000 times higher than the conductivity of a pure silicon crystal?

(3p)

Good Luck !