LULEÅ UNIVERSITY OF TECHNOLOGY
Applied Physics

Course code	**F0053T / F0019T (old)**
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 Tel: (49)2291, Room E303
Examiner: Hans Weber Tel: (49)2088, Room E163

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. **Hydrogen like spectra**

   The Institutet för rymdfysik (IRF) in Kiruna has at the moment active instruments at several different planets in our solar system. One of the instruments detects the following spectra in ultra violet light emitted from a carbon rich area.

λ (nm)	207.80	129.63	104.20	91.84

   At IRF they note that the lines listed above very much appear to be like a hydrogen spectra. It is suggested the spectra originates from highly ionized carbon with only one electron left and that the lines belong to the same series ie they all have the same lower level with principal quantum number n and one may assume the upper levels are adjacent. Determine the principal quantum numbers for the levels involved in the transitions listed above. (3p)

2. **Time evolution of solution**

   A particle of mass m, which moves freely inside a one–dimensional infinite square well potential of length a, has the following initial wave function at time $t = 0$:

$$\psi(x,0) = \frac{A}{\sqrt{a}} \sin\left(\frac{\pi x}{a}\right) + \frac{1}{\sqrt{5a}} \sin\left(\frac{5\pi x}{a}\right)$$

   where A is a real constant.

   a) Find A so that $\psi(x,0)$ is normalised.

   b) If a measurement of the energy is carried out at $t = 0$, what are the values that can be found and what are the corresponding probabilities? Calculate the average energy of the particle $< E >$.

   c) Find the wave function $\psi(x,0)$ at any later time t.

   (3p)

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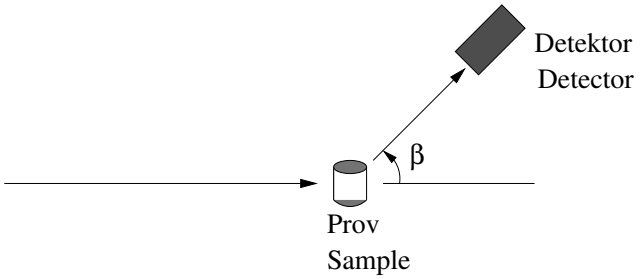

Figure 1: Principal drawing of the scattering settup

3. **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)

4. **Crystal structure** Aluminum, Chrome and Germanium are chemical elements with different crystal structures.

   (a) How many atoms does the primitive unit cell contain in these elements?

   (b) How many atoms does the conventional unit cell contain in these elements?

   (c) Calculate the nearest and next nearest neighbour distance, in Ångström, for Germanium.

   (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 β where the diffraction peaks are found. Identify the cubic crystal structure. In Figure 1 the setup is shown.

β	30.3°	43.4°	53.9°	63.1°	71.6°	79.7°	87.6°

   (3p)

Good Luck !