LULEÅ UNIVERSITY OF TECHNOLOGY
Division of Physics

Course code	**F0047T**
Examination date	2019-01-15
Time	15.00 - 20.00 (5 hours)

Examination in: KVANTFYSIK / QUANTUM PHYSICS
Total number of problems: 5
Teacher on duty: Hans Weber Tel: (49)2088, Room E163
Examiner: Hans Weber Tel: (49)2088, Room E163

Allowed aids: Fysika, Fysikalia, Physics Handbook, Beta, calculator, COLLECTION OF FORMULAE

Define notations and motivate assumptions and approximations. Present the solutions so that they are easy to follow. Maximum number of points is 15 p. 8.5 points are required to pass the examination. Grades 3: 8.5, 4: 10.5, 5: 12.0 . This includes the bonus points from the three home assignements.

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1. **Two dimensional Square well**

   A particle is placed in the potential (a 2 dimensional square well)

$$V(x) = \begin{cases} 0 & \text{for} \quad 0 \leq x \leq a \text{ and } 0 \leq y \leq a \\ \\ +\infty & \text{for} \quad x > a,\ x < 0 \text{ and } y > a,\ y < 0. \end{cases}$$

   (a) Calculate (solve the Schrödinger equation) the eigenfunctions ?

   (b) What are the 4 lowest eigenenergys ?

   (c) What are the degeneracys of these 4 lowest eigenstates ?

   (3p)

2. **Early model of the nucleus of an atom**

   In the early days it was thought that the nucleus of an atom also contained electrons as they where emitted in a β decay. Today we know this is not the case. Make a reasonable estimate of the kinetic energy of an electron confined to a box of an approximate size of 1 fm (the size of a nucleus) ? Give your answer in eV !

   (*Hint*, start with a choice of an appropriate model for your calculation. Motivate choice.)

   (3 p)

TURN PAGE!

3. **Spin**

Suppose a spin 1/2 particle is in the state

$$\chi = \frac{1}{\sqrt{6}} \begin{pmatrix} 1+i \\ 2 \end{pmatrix}.$$

(a) What are the probabilities of getting $+\hbar/2$ and $-\hbar/2$, if you mesure S_z?

(b) What are the probabilities of getting $+\hbar/2$ and $-\hbar/2$, if you mesure S_x?

(3p)

4. **Angular momentum**

Suppose an electron is in a state described by the wavefunction

$$\psi = \frac{1}{\sqrt{4\pi}} \left(e^{i\phi} \sin(\theta) + \cos(\theta) \right) g(r),$$

where

$$\int_0^\infty \mid g(r) \mid^2 r^2 dr = 1,$$

and ϕ, θ are the azimuth and polar angles respectively.

(a) What are the possible results of a measurement of the z-component L_z of the angular momentum of the electron in this state?

(b) What is the probability of obtaining each of the possible results in part (a) ?

(c) What are the expectation values of L_z and L^2 ?

(3p)

5. **Hydrogen like spectra**

The Institutet för rymdfysik (IRF) in Kiruna has at the moment active instruments at four 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)

GOOD LUCK !