LULEÅ UNIVERSITY OF TECHNOLOGY
Division of Physics

Course code	F0047T/MTF107
Examination date	2011-03-15
Time	09.00 - 14.00 (5 hours)

Examination in: KVANTFYSIK / QUANTUM PHYSICS
Total number of problems: 5
Teacher on duty: Johan Hansson Tel: 491072, Room E300
Examiner: Hans Weber Tel: 492088 or 0708-592088, Room E304

Allowed aids: 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 point is 15 p. 7.0 points are required to pass the examination. Grades 3: 7.0, 4: 9.5, 5: 12.0

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1. **Compton scattering**

   A 100-keV photon collides with an electron at rest. The photon is scattered through $\theta = 90^o$. (Note, in the figure 1 below the angle is not 90^o)

   (a) What is its energy and wavelength of the photon after the collision?

   (b) What is the kinetic energy in eV of the electron after the collision?

   (c) What is the direction of the recoil (electron) ?

   (3p)

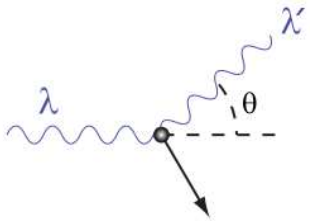

Figure 1: Compton scattering of a photon of wavelength λ through an angle θ to a photon of wavelength λ'.

2. **Angular momentum**

   For a Nitrogen molecule calculate the change in angular momentum as it emits a photon of wavelength $\lambda = 1250\mu$m. The transition is between two close rotational levels. The distance between the Nitrogen atoms in the molecule is d=1.094 Å. The angular momentum of level l is given by $\sqrt{l(l+1)}\hbar$.

   (3p)

TURN PAGE!

3. **Spin**

Evaluate for a spin 1/2 particle described by the spinor χ the expectation values of the 3 cartesian components ($< S_x >, < S_y >, < S_z >$) of the spin and also their squares ($< S_x^2 >, < S_y^2 >, < S_z^2 >$)

$$\chi = \frac{1}{3}\begin{pmatrix} 2-i \\ 2 \end{pmatrix}.$$

(3p)

4. **Quantum rotator**

The Hamiltonian (in units of eV) for a given axially symmetric quantum rotator is

$$H = \frac{L_x^2 + L_y^2}{3\hbar^2} + \frac{L_z^2}{4\hbar^2}$$

What are the possible energies? (3p)

5. **Three–dimensional box well**

A particle is placed in the potential (a 3 dimensional box well)

$$V(x,y,z) = \begin{cases} 0 & \text{for} \quad 0 \le x \le a \text{ and } 0 \le y \le a \text{ and } 0 \le z \le \frac{\mathbf{a}}{\mathbf{2}} \\ \\ +\infty & \text{for} \quad x > a \text{ or } x < 0 \text{ or } y > a \text{ or } y < 0 \text{ or } z > \frac{\mathbf{a}}{\mathbf{2}} \text{ or } z < 0. \end{cases}$$

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

(b) What are the 7 lowest eigenenergies ?

(c) What are the degeneracies of the states associated to these 7 lowest eigenenergies ?

(3p)

GOOD LUCK !