THINGS I EXPECT YOU TO KNOW AFTER COMPLETING THIS MODULE

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This handy little document will help you in preparing for the exams and tests. Listed below you will find a rough layout of the minimum that I expect you to know by the end of this module. This is a chech list which you can now use to gauge whether you are ready for the exam or tests. The sections indicated in **bold** are the key concepts of this module.

1. Relativity

You must

- be comefortable with classical relativity and the speed of light
- understand and interperet the Michelson-Morley experiment
- state the postulates of relativity
- be able to derive the equations of **time dilation and length contraction** and use them to solve problems
- be able to use and derive the Lorentz transformations
- be able to use and derive the relativistic velocity addition formulas
- understand mass in relativity
- derive and use relativistic momentum and energy
- derive the **"Pythagorean Relation"** and be able to use it
- derive and use force in relativity
- understand the mechanics of massless particles
- be able to distinguish when to use relativistic and nonrelativistic mechanics
- have a general idea about general relativity, such as stating the equivalence principle

2. Quantum mechanics

Here you must

(1)
- be familiar with some of the atomic parameters including the **atomic mass unit**
- be able to derive and use the formula for the mean free path
- grasp the experiment used by Thomson to discover the electron

(2)
- understand the concept of quantization
- understand Plack and **black body radiation**
- grasp the **photoelectric effect** and use it
- understand x-rays
- derive **Bragg's law** and be able to use it
- be able to interpret x-ray spectra
- be able to derive the **Compton formula** and use it

- understand and be able to use the **particle wave duality**

(3)
- understand atomic spectra
- be able to derive the **Balmer-Rydberg formula** and use to solve problems
- understand the problem of atomic stability
- uderstand **Bohr's explanation of atomic spectra**
- be able to derive the formulas **Bohr used in his model**
- understand the **properties of the Bohr atom**
- apply the results of Bohr to hydrogen like ions
- understand the evidence for atomic energy levels

(4)
- understand **De Broglie's hypothesis**
- understand the **quantum wave function** and its experimental verification
- understand the double slit experiment and all its concequences
- be familiar with the workings of sinusoidal waves
- be able to use **Fourier analysis** to solve problems with wave packets
- be able to derive and use the **uncertainty relations**
- understand and be able to use the velocity of wave packets

(5)
- understand classical standing waves
- understand how standing waves will look in quantum mechanics
- **stationary states** in quantum mechanics
- be able to determine the **allowed energies** for the particle in the **rigid box** using the SE and by just using standing wave arguments
- be able to use the **TISE** NB!!
- be able to solve and comment on the results of the energies of a free particle
- find the solutions of **TISE** for the **nonrigid box** and allowed energies
- understand the workings of the quantum simple harmonic oscillator and be able to draw the wave functions
- understand why the quantum simple harmonic ocsillator is such an important example
- derive formulas for **tunneling** and be able to use those to solve problems NB!!

(6)
- be able to solve the **two dimensional SE** for infinite potential using the **separation of variables** method and the **determinant method** which we did in class
- be albe to solve the **2D central force** problem and derive the laplacian
  $\nabla^2 = \frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r} + \frac{1}{r^2}\frac{\partial^2}{\partial \phi^2}$
  in polar coordinates
- be able to set up the **3D central force** problem and comment why this is such an important example
- understand and derive formulas regarding the **quantization of angular momentum**

- be able to derive the **energy levels** of the H-atom (heuristically) and interpret them
- be familiar with using hydrogenic wave functions
- be familiar with the concept of shell model
- be able to find solution of the allowed energies for hydrogen like ions

(7)
- understand angular and **spin** angular momentum
- be able to derive formulas for the **magnetic moment** and use them
- understand the **Zeeman effect**
- understand and derive the spin magnetic moments
- understand the **anomalous Zeeman effect**
- understand and interpret the **Fine Structure**
- hava a basic idea about the workings of **M**agnetic **R**esonance **I**maging (MRI)

(8)
- Know the workings of the Independant Particle Approximation (IPA)
- Know and be able to apply the **Pauli Exclusion principle**

(9)
- Understand simple nuclear properties, which include:
  - nuclear constituents
  - sizes and shapes of nuclei
  - nuclear energy levels
  - angular momenta of nuclei
- understand the nuclear force, this includes the charge independance
- understand why **neutrons rather that electrons** are nuclear constituents
- be able to calculate the energies of nuclear constituents
- be albe to describe the IPA potential energy for nucleon
- be able to describe the **Pauli principle** and **symmetry effect**
- be able to derive and use the semiempirical Binding-Energy formula
- understand the shell model of the nuclues
- understand the workings of a mass spectrometer

(10)
- be able to describe the different types of radioactive decay (α, β, γ)
- be able to derive the exponential decay law
- apply exponential decay law in problems regarding radiocarbon dating
- understand where the **neutrino** can from and how it was discovered
- understand the natural radioactive series
- understand the discovery of the proton and neutrons
- understand reactions made in man made accelerators
- be able to calculate nuclear cross sections
- understand the concept of nuclear fission
- understand nuclear fusion
- understand the theory of α-decay

I will see where we get to by the end of the lectures, most probably we won't be able to cover all the concepts mentioned in the final section.