KING SAUD UNIVERSITY. DEPARTMENT OF PHYSICS

MODERN PHYSICS LAB (HW№2-4)

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Select 3 experiments that you studied, and submit them as a Homework

PROBLEM SET (1) PHOTOELECTRIC EFFECT

1. What is the fundamental assumption that the photoelectric effect is explained upon, what is its relation quantum theory ?
2. Describe a proposed experiment to use the photoelectric effect to measure Plank's constant h, draw a hypothetical plot for the calculation and the experimental setup.
3. Photon of energy $3,5$ eV, calculate its frequency and wavelength.
4. A light of wavelength $\lambda = 457,5$ nm on a photoelectric cell, and a 1 Volt tension was produced by the cell, what is the work function of this cell ?
5. (bonus question) The exact way the incident photon γ interacts with the electron in the atom causing the photoelectric effect is very complicated, and one needs to use q*uantum electrodynamics* (QED) in order to fully describe it.
   Using QED, we can write the 'probability' for the photon indecent, causing the photoelectric effect via a cross-section, which is given by:

   $$\sigma = K\, Z^n E^{-3,5}$$

   Where $K = const.$ and n varies between 4 and 5.
   Plot the cross-section for 3 elements, consider $Z = 11,19,37$ for example. Design the Plot such that you do not care about K and the energy in MeV. Comment on the Plot in 2-3 lines maximum.

PROBLEM SET (2) X-RAYS

1. Describe how x-rays are usually generated, in particular the Bremsstrahlung process.
2. Why does Moseley laws law provide an evidence for the atomic theory of Bohr ?
3. (bonus question) What are K,L and M lines you discovered in the Moseley's law experiment ?
4. What is the Duane Hunt maximum x-ray frequency of a excitation voltage $V = 6kV$?
5. Draw a basic shape of the x-ray absorption spectrum of a generic element, denote the β and α lines along with Duane-Hunt cutoff

PROBLEM SET (3) BLACKBODY RADIATION

1. What is meant by a 'black' body ? How can we make an almost ideal blackbody in the lab ?
2. What is the UV catastrophe ? How it was solved ?
3. Draw the black body spectrum, and indicate its main characteristics
4. State the mathematical description for Wien displacement law, how this is tested in the lab ?
5. Starting from the Plank distribution,

$$B_\lambda(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$

   Derive Wien displacement law by maximizing the distribution.
6. (Bonus question) Use the Plank distribution to derive the Stefan-Boltzman Law.

PROBLEM SET (4) ZEEMAN EFFECT

1. What is degeneracy ? How degeneracy exist in the Hydrogen atom, and how Zeeman effect removes this degeneracy?
2. Write the energy (Hamiltonian) term than contribute to the Zeeman effect.
3. Why the Fabry–Pérot interferometer was used in the experiment to detect Zeeman effect?
4. How many spectral line splitting we expect for the ordinary and anomalous Zeeman effects, respectively.
5. (bonus question) An effect of energy shift due to an electric field is also known and called the Stark effect. Describe this effect in few lines and needed equations/ graphs.

PROBLEM SET (5) INTERFERENCE

1. How Michelson interferometer was used to show that the ether does not exist ?
2. What is the sodium D-line , and what interferometer is used to observe it ?
3. Derive the mathematical conditions for destructive and constructive interference.
4. What is the phase of a wave, and how a phase difference emerges from a path difference ?

PROBLEM SET (6) MICROWAVES

1. What is the wavelengths and frequency ranges for the microwaves ?
2. Draw a standing wave and denote the components of it.
3. How do standing waves get generated ? (using mathematical expressions to explain that yields a bonus point)
4. Draw a simple diagramme showing the complete electromagnetic spectrum.

PROBLEM SET (7) HYDROGEN SPECTRUM

1. Deduce the Rydberg formula from the Hydrogen atom energy levels.
2. We usually denote the Rydberg constant by R_∞, when we take the limit in which the nuclear mass is infinite compared to the electron's. If we want to consider the mass of the nucleus to be finite, we use the reduced mass instead of the electron mass.
   Derive the reduced Rydberg constant in this situation.
3. What are the ranges of the Balmer series wavelengths, use the Rydberg formula to deduce them.
4. In which part of the electromagnetic spectrum does Lyman and Baschen series lie in ?

PROBLEM SET (8) FRANK-HERTZ EXPERIMENT

1. Draw the Frank-Hertz experiment set up and comment on each part
2. Draw the Frank-Hertz experiment energy spectrum, and explain how it is related to the qunatisation of energy
3. Why we heat the vacuum tube before we preform the experiment ? How that can be avoided ?

PROBLEM SET (9) FARADAY EFFECT

1. What is the polarisation of light, draw an EM wave in order to clarify your explanation
2. what is the difference between the magnetic field **H** and the magnetic flux field **B** ? In vacuum and in a the matter.
3. In few lines, explain the Faraday effect, and use a simple drawing to illustrate it.
4. Is there other effects that could be considered similar to Faraday effect, mention an example.