Faculty of science Physics department	Semiconductor physics, thin films and its application (451p) Date: 15/1/2020 time: 3 hrs	

Answer the following questions:

1. (a) Explain **three** of the following (preparation, characterization and application) :

1. Light emitting diodes.
2. Solar cells.
3. Semiconductor laser diode.
4. Photodiode and photo-detector.

(b) The complex dielectric constant of *Cd S* is given by the relation:

$$\varepsilon^* = 8.5 + i\,4.8$$

At wavelength $\lambda = 560$ nm. Deduce the refractive index (n), the phase velocity (υ), the extinction absorption coefficient (α) and the reflectivity (R).

(10 mark)

2. (a) Drive an equation for the density of holes in an intrinsic semiconductors.

(b) Discuss **shortly** the different types of exciton absorption process in semiconductors.

(10 mark)

3. (a) Explain in details **two** of the following:

1. Generation and recombination process of free charge carriers in semiconductors.
2. Diffusion and drift currents.
3. Hall effect and its applications.

(b) Calculate the position of Fermi level at 400 K for Ge crystal containing 5×10^{22}arsenic atoms/m^3. Also, calculate the conductivity if the mobility of the electron is 0.39 $m^2\,V^{-1}sec^{-1}$ and $e = 1.6\times10^{-19}$ C.

(10 mark)

4. (a) Deduce an expression for allowed and forbidden direct optical absorption transitions.

(b) Determine the position of Fermi level and calculate the density of holes and electrons for CdS intrinsic semiconductor at 450 ^oK with energy gap $E_g = 2.4$ eV, $m^*_p = 6\, m^*_e$ and $C=4.83*10^{22}$.

(10 mark)

5. (a) Write an essay on the different types of thin films experimental techniques

(b) Explain how you can determine the minority carriers life time using A.C. photoconductivity measurements.

(10 mark)

With my Best Wishes

Prof. M. A. Osman

Assiut University
Faculty of Science
Physics Department

Exam date 09/01/2020

Term: Fall 2019 - 2020
Quantum Mechanics P411
Time allowed: 3Hours

Answer the following question: (*all questions carry the same weight 10 points*)

Question #1

Solve the harmonic oscillator by the method of the lowering and raising operators, which are defined as the Linear combination of the momentum and position :

$$\hat{a}_{\pm} = \frac{1}{\sqrt{2m\hbar\omega}}(\mp i\hat{p} + m\omega x)$$

a) ***Prove*** that $[\hat{a}_-, \hat{a}_+] = 1$ (You need to show it step by step).

b) ***Prove*** $\hat{H} = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + \frac{1}{2}m\omega^2 x^2 = \hbar\omega\,(\hat{a}_-\hat{a}_+ - \frac{1}{2}) = \hbar\omega\,(\hat{a}_+\hat{a}_- + \frac{1}{2})$.

c) ***Show*** that if $\hat{H}\psi = E\psi$, then $\hat{a}_{\pm}\psi$ is also eigenfunction with eigenenergy $E \pm \hbar\omega$.

Question #2

A particle is described by the wavefunction

$$\psi(x) = \begin{cases} A\cos\left(\frac{2\pi x}{L}\right) & for\ -\frac{L}{4} \le x \le \frac{L}{4} \\ 0 & otherwise \end{cases}$$

a) ***Determine*** the normalization constant A.

b) ***What*** is the probability that the particle will be found between x=0 and x=L/8 if we measured its position?

c) ***Find*** the expectation values for operators x, p, and p^2.

Question #3

a) From separation of variables applied to the time-independent Schrödinger equation, we have:

$$\frac{1}{R(r)}\frac{d^2}{dr^2}\left(r^2\frac{dR(r)}{dr}\right) - \frac{2mr^2}{\hbar^2}[V(r) - E] = \ell(\ell+1)$$

for integer ℓ. ***Transform*** to the new function $u(r) = r\,R(r)$, and ***show*** that the above can be written as:

$$-\frac{\hbar^2}{2m}\frac{d^2u(r)}{dr^2} + \left[V(r) + \frac{\hbar^2}{2m}\frac{\ell(\ell+1)}{r^2}\right]u(r) = E\,u(r)$$

Question #4

a) For Hydrogen-like atoms, ***show*** that $\langle r\rangle = \frac{3a_o}{2Z}$ and $r_{mp} = \frac{a_o}{Z}$ for the ground state.

b) ***Show*** for a 2p state $\langle r\rangle = \frac{3a_o}{2Z}$.

$$\left(\text{where } \psi_{1s} = \frac{1}{\pi}\left(\frac{z}{a_o}\right)^{3/2} e^{-zr/a_o} \text{ and } R_{21} = \frac{1}{\sqrt{24}}\left(\frac{z}{a_o}\right)^{3/2}\frac{zr}{a_o}e^{-zr/a_o}\right),$$

Question #5

a) *Prove that the radial wave function* $R_{30}(r)$ is given by:

$$R_{30}(r) = \frac{a_0}{3a}\left(1 - \frac{2}{3}(r/a) + \frac{2}{27}(r/a)^2\right) e^{-r/3a}$$

b) *Normalize* $R_{30}(r)$ and *construct* $\psi_{300}(r,\theta,\phi)$.

$$\left(Y_0^0(\theta,\phi) = \frac{1}{\sqrt{4\pi}} \right)$$

***** ***** ***** ***** ***** ***** ***Good Luck*** *** ***** ***** ***** ***** *****

Prof. Dr. A. A. Ebrahim

Assiut University
Faculty of Science
Department of Physics
First semester 2019-2020

Exam in 5 pages

Course: *Magnetic Resonance and Mossbauer Spectroscopy*
Code: 422P
Time: 3 Hours
Final Exam (50%)

Use the following physical constants when you need:

Electron charge $e = 1.6x10^{-19}$ *Coulomb*, **Electron mass** $m_e = 9.11x10^{-31}$ *kg*,
Proton mass $m_p = 1.673x10^{-27}$ *kg*, **Planck's constant** $h = 6.626\,x10^{-34}$ *J.s*
The gyromagnetic ratio of H^1, $g = 5.586$ *Boltzmann Constant k =1.38 x 10^-23 J/K*

Section (A): (20 points - 30 marks)

Circle the correct answer:

1. The free precession of a magnetic moment around a magnetic field is defined by
(a) TheBohr magneton (b) The Larmor frequency (c) The angular momentum

2. The L-S coupling splits the *d*-electrons levels $(l=2)$ to
(a) six energy levels with $j=5/2$ (b) two groups with $j=5/2$, $j=3/2$
(c) four energy levels with $j=3/2$

3. The Larmor frequency of a magnetic moment around a magnetic field is
(a) proportional to the applied magnetic field
(b) inversely proportional to the applied magnetic field
(c) proportional to the exciting photon energy

4. The number of resonance frequencies in the ESR experiment in the case of $l=2$ and $s=1/2$ is
(a) one transition frequency (b) two transition frequencies
(c) five transition frequencies

5. The energy required for the NMRof the hydrogen nucleus in a magnetic field is usually in the
(a) Radio wave range (b) Microwave range (c) Ultraviolet range.

6. The magnetic moment of an electron spin μ_z is
(a) $1/2\ \mu_B$ (b) μ_B (c) $3/2\ \mu_B$

7. When a magnetic field is applied to electrons at room temperature,
(a) all the electron spins will have direction parallel to the applied magnetic field.
(b) only a part of electron spins will have direction parallel to the applied magnetic field.
(c) electron spins will have random orientations.

8. In a magnetic resonance experiment, a static magnetic field is applied for
(a) the splitting of the energy levels
(b) the resonance transition between the energy levels
(c) none of the above

9. In an ESR experiment, the resonance transition between the energy levels is maintained by
(a) an applied magnetic field (b) exciting microwaves (c) exciting radiowaves

10. The ratio of the nuclear magneton to the Bohr magneton μ_N / μ_B is equal to

(a) m_p / m_N (b) m_e / m_p (c) m_p / m_e

11. In an ESRexperiment under constant excitation energy, the resonant magnetic field is
(a) directly proportional to the g-factor
(b) inversely proportional to the g-factor
(c) doesn't depend on the g-factor

12. For a magnetic field of 2.348 T, H^1 resonates at:
(a) 100 GHz (b) 65.744 MHz (c) 100 MHz

13. Spin-lattice relaxation time is normally
(a) shorter than spin-spin relaxation time
(b) longer than spin-spin relaxation time
(c) In the range of spin-spin relaxation time

14. The spin-spin relaxation time refers to
(a) the energy conducted to the lattice (b) the dephasing time
(c) neither of them

15. According to Hund's rule, triplet is ....in energythan a singlet state
(a) higher (b) lower (c) neither of them

16. Symmetric spatial wave function of two electrons has .... energy than asymmetric wave function
(a) higher (b) lower (c) neither of them

17. For a given multiplicity, the largest value of L has
(a) high energy because the two electrons circulate in the same direction
(b) low energy because the two electrons circulate in opposite directions
(c) low energy because the two electrons circulate in the same direction

18. Higher angular momentum state (L) is lower in energy due to
(a) spin-spin interactions (b) orbit-orbit interactions
(c) spin-orbit interactions

19. The total energy angular momentum state (J) is lower in energy due to
(a) spin-spin interactions (b) orbit-orbit interactions
(c) spin-orbit interactions

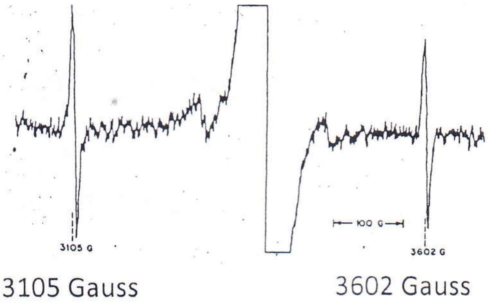
20. The time required for the magnetization to return to thermal equilibrium, or $M_z$grows to M_0, is described by
(a) the spin-spin relaxation time (b) the transverse relaxation time
(c) the spin-lattice relaxation time

Section B (20 marks):
Answer four of the following five questions

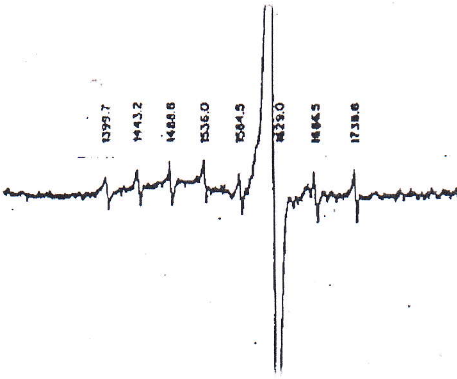
1) An atomsis in a $^2D_{3/2}$ state. What is the magnetic moment μ_J and the possible values of the z component of the magnetic moment μ_{Jz} for each one.

2) Draw the energy level diagram of the deuterium atom S(1/2) and I(1) resulting from the hyperfine coupling in a constant magnetic field and show that the expected spectrum is triplet

3)The following figure shows the ESR spectrum of hydrogen atoms in an x-rayed human tooth at room temperature, Calculate the hyperfine coupling of the hydrogen atom and the exciting photon energy.



4) In an ESR spectrum of Fe^{+} and Co^{++}, The Fe^{+} spectrum consists of a single intense line while the Co^{++} spectrum is a hyperfine octet due ^{59}Co with I = ½. If the exciting photon energy is 9.4175 GHz and for the magnetic field at the center of the intense line (Fe^{+})is 1629.06 G, calculate the g factor of Fe^{+}.



5) Write the Bloch equations for the system of magnetic moments excited by photons in a constant magnetic field Hin case of damping.

....

Best wishes

Examiner: Prof. Dr. Mohamed Almokhtar

Assiut University
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Physics Department

The Final Exam for
Amorphous &Glassy Materials
(P457)

Fourth Year
Time: 3 h
Date :26-12-2019

Answer Five only from the following questions: "50 Marks"

Part.1: Answer this question: (10 Marks)

Choose the correct answer for these statements:

1- In DSC thermographs, during the crystallization process of amorphous solids, the enthalpy of the sample generally undergoes:

a)-Decrease b)- Increase

c) Strong decrease. d)-Remain the same

2- We can easily obtain binary chalcogenide glass through melt quench technique using:

a)- Se,Ag b)- Te,Pb c)- Se,Te d)- S,Sn

3- During preparing thin films using CVD technique, the source material (s) must be in the form of :

a)- Single crystal b)- Amorphous solid c)- Gases d)- Solutions

4- During Soda-Lime –Silicate glass production, the addition of Soda and Lime to Silica result in :

a)- Raising the melting temperature b)- Increase the glass temperature

c)- Decreasing the viscosity d)-Easy glass formation

5- The absorption coefficient of amorphous thin films depends on :

a)- Type of the material b)-Wave length of the incident photons

c)- Film thickness d)- All the above mentioned

6- For amorphous semiconducting material thin films of band gap 1.2 e V, band to band electron absorption takes place for wave length in the range:

a)-IR region b)- UV region c)- Vis region d)- FIR region

7-Glass former elements usually are of high valance state and forms with oxygen:

a)- Covalent bonds b)- Ionic bonds c)- Metallic bonds d)-a and b

8-Extended state conduction usually takes place :

a)- In single crystalline semiconductors b)- Between dopants atoms at low temperature c)-Between localized states at fermi level

d)-In doped amorphous semiconductor materials

9- During exothermic process in the DSC experiment under non isothermal conditions:

a)-Weakly bonded molecules are converted to strongly bonded molecules.

b)-The temperature of the surrounding decreases.

c)-Heat is converted into chemical potential energy

d)-The temperature of the sample increases

10-In order to detect the exact chemical composition of an amorphous solid we must use:

a) X-ray diffraction (XRD).

b)-Thermogravimetric analysis (TGA)

c)- Energy dispersive spectroscopy(EDS)

d)- electron diffraction (ED)

Part.II: Answer Four Only from the following questions (All questions are of equal marks 10 Marks for each):

Q.1:

1-a)- State briefly the reason(s) for the following:

I)- Addition of Sod-ash to SiO_2 during glass production is very important.

ii)- Amorphous solids soften over a range of temperature while crystalline solids soften at definite temperature.

iii)- The density of Cs containing silicate glass is greater than that of pure silicate glass.

1-b)- Discuss the changes that can take place for the :

i)- Bond sketch diagram
ii)-The overall properties
when Alkaline earth oxide(s) added to silicate glass.

2:

2-a)- Write a mathemical expression for the following:

i)- The free volume (V_f) of a glass:

....

ii)- The temperature dependence of ionic conductivity for amorphous solids in the presence of external electric field (E>0):

....

iii)-The Abbe number (ν-number) describing the chromatic dispersion of glass:

....

iv)- The Urbach relation describing band tail absorption of photons in amorphous semiconductor.

....

v)- The optical loss parameter (P) of a glass:

....

2-b)-Discuss the optical loss/ attenuation mechanisms in these materials :

Semiconductor optoelectronics, soda –lime glass in the IR region and Fiber-optic glass.

Q.3:

3-a)-Compare between resistive heating and plasma ionic sputtering techniques for amorphous thin film deposition.[your answer should include: (simple sketch diagram, main idea, advantageous and disadvantageous) for each].

3-b)-Explain briefly the steps that must be followed to prepare 10grams of $Ge_{50}Se_{50}$ bulk amorphous alloy using melt-quench technique.

[Note; M.Wet of Ge and Se are 72.61 and 78.96 respectively]

Q.4:

4-b)-Express through graphic presentation (E Vs DOS) diagram the different types of photo electronic absorption in doped amorphous semiconductor. Then, explain how you can use the absorption coefficient (α) Vs hμ data to calculate:

i)- The optical energy gap E_g . ii) The band tail width E_e .

4-b)- Using only the sketch diagrams to express the following:

i)-Cooling curves of amorphous and crystalline solids.

ii)- Electron beam technique for thin film deposition.

iii)- Enthalpy change during cooling of super cooled glass melt at different cooling rates.

Q.5:

5-a)- Write on two parts only from the following:

i)- Chalcogenide glasses and their properties.

ii)- Pauling,s rules for polyhedron glass formation.

iii)-Flout process for production of mirror and window glasses.

5-b)- plot a hypothetical DSC thermographs (ΔH Vs T) for a homogenous glassy sample at different heating rates from room temperature to above the melting point of this material. After that explain the following:

i)-What happen to the ample and the surrounding at each state of the thermographs.

ii)-How you can calculate E_c or E_g by extracting some data from these thermographs using Kissinger formula.

With my best wishes Prof. Dr. Atta . Y. Abdel-latief