Assiut University
Faculty of Science
Physics Department

Quantum Mechanics

January 2018
B. Sc. Physics
Time: 3 hrs.

ANSWER ONLY FOUR QUESTIONS:

1) - Consider a potential step $V(x) = \begin{cases} 0 & \text{at } x < 0 \\ V_o & \text{at } x > 0 \end{cases}$

Prove that for $E > V_o$ **, the reflection coefficient would be given by**

$$R = \left[\frac{k_1 - k_2}{k_1 + k_2}\right]^2$$

2) – In the energy representation, find the energy levels of the linear harmonic oscillator $V(x) = \frac{1}{2}kx^2$ **, k is a constant**

$$[Hint: \gamma = (2E\sqrt{m}/\hbar\sqrt{k}),\ y = (mk/\hbar^2)^{1/4}\, x\ ]$$

3) – Find the energy levels and the corresponding eigen functions of a three dimensional problem by solving the wave equation in cartesian coordinates. What is the degeneracy of each level?

4) – Derive the nonrelativistic probability current density of quantum mechanics.

5- Show that the eigen functions of hydrogen atom

$$\Psi_{200} = \frac{1}{\sqrt{\pi}}\left(\frac{z}{2\alpha_o}\right)^{3/2}\left(1 - \frac{zr}{2\alpha_o}\right)e^{-zr/2\alpha_o}$$

$$\Psi_{211} = \frac{1}{8\sqrt{\pi}}\left(\frac{z}{\alpha_o}\right)^{5/2} re^{-zr/2\alpha_o}(\sin\theta)e^{i\phi}$$

are orthogonal to each other

$$[Hint: d\tau = r^2 \sin\theta\, dr\, d\theta\, d\phi]$$

Good - Luck

Assiut University
faculty of Science
Physics Department

The final Exam in
Amorphous and Glass Materials
(P457)

For the 4th level Phys.
Time:3 h
Date:25-12-2017

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

Part. I: Answer this question

Choose the correct answer for these statements: (10 Marks)

1- The viscosity (η) of the materials when transform from liquid to solid state undergoes.
a) strong decrease b) strong increase c) slight increase
d) slight decrease

2- In the glass transition region, the temperature of the material generally
a) Decrease b) Increase c) Remain the same
d) None of these

3- The coordination number for the octahedral structure glass is
a) 4 b) between 2 – 3 c) > 4 d) 0.22 – 0.41

4- The most easy and popular technique used to prepare amorphous thin films
a) Melt quenching b) CVD c) thermal evaporation d) b and c.

5- The refractive index of glass increases with decreasing
a) Moral volume (V_m) b) cooling rate
c) Glass density (ρ) d) all these

6- Band to Band absorption in amorphous semiconductors generally takes place for wavelength in spectral range
a) IR b) UV c)VIS d) FIR.

7- For any compound a glass can be easily formed if the average coordination number of the compound equals:
a)2. 4 b) 3 c) 2.6 d) 1.8

8- Variable range hopping conduction takes place:
a) between nearest neighbor atoms b)between localized states near E_f
c) between dopant atoms at low temperature d) all these

9- For exothermic process in the DSC thermos-gram, the chemical potential energy in the glassy sample changes to:
a) heat the sample b) decrease of the surrounding temperature
c) $\Delta H > 0$ d) $\Delta H < 0$

10- The optical absorption in glasses for the IR region of the spectrum is due to:
a)electronic transition b) vibrational transition
c) a and b d) None of these.

Part II : Answer Four only from the following questions **(40 Marks)**

Q.1: **(10 Marks)**

a) Define the following:

Glass network former – Intermediate – Hopping frequency – Mean dispersion – Raylech scattering

b) – Compare between silicate (SiO_2) and borate (B_2O_3) glasses with no modifiers added – what changes in the structure would occur if :

i) Alkali oxide **ii) Alkaline earth oxide** **iii) Alumina (Al_2O_3) were added to these glasses.**

Q.2: **(10 Marks)**

a- Write a mathematical expression for the following statements:

1- The free volume (V_f) of glass:

.....

2- The average coordination number (m) of a binary alloy A_xB_{1-x}

.....

3- The Abbe number (υ) as a measure for dispersion in a glass

.....

4-The Einstein relation (in 3-D) for ionic conductivity σ when E > 0

.....

5-The Kissinger relation generally used to calculate the activation energy for a transformation process using DSC data under non isothermal condition.

.....

b- Explain briefly one method generally used to prepare :

i) Amorphous bulk glass

ii) Amorphous thin film

Q.3: **(10 Marks)**

a- According to the constraint theory for glass formation, prove which of these compounds is (are) a good glass former

i) $Se_{70}Si_{30}$ **ii) As_2S_3**

(Note: the coordination numbers of the elements Se, Si, As and S are 2, 4, 3, 2 respectively)

b- Compare between extended state and variable range hopping conduction mechanisms in amorphous semiconductors

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Q.4: **(10 Marks)**

a- Using sketch diagram explain the steps generally take place during the float process method for production of windows and mirror glasses. Have you any idea about smart glasses for future applications?

b- Explain how you can use the experimental data of the absorption coefficient (α) vs $h\upsilon$ of spectrum in the UV –IR range for amorphous semiconductor sample to calculate

i) **The optical energy gap (E_g)**
ii) **The Urbach band tail (Ee)**

Q5: **(10 Marks)**

Discuss in brief the optical loss (attenuation) mechanisms in these materials

i) **Amorphous optoelectronic semiconductors**
ii) **Soda – lime glass**
iii) **Transparent ceramics**

b- Plot a sketch for DSC diagram under non-isothermal condition from room temperature to above the melting point of a glassy sample

- **Explain what happen at each stage to the sample and the surrounding**
- **How you can calculate E_t and E_c using Kissinger relation**

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

Assiut University
Faculty of Science
Department of Physics

Undergraduate
Final Exam (50%)

First semester 2017-2018

Course : Selected Topics in Physics (1)
Code : P491
Section : Physics
Time : 3 Hours
Date : 2/1/2018

Answer five (5) only of the following questions:

Question (1): (10 Mark)

a) Define the electric polarization. (1 points)

b) Prove that the bound surface charge density σ_b is equal to the normal component of electric polarization $\vec{P}$ at the surface. (3 points)

c) Derive an expression of the bound volume charge density is given by ρ_b. (4 points)

d) Derive Gauss Law in differential form for electric displacement. (2 points)

Question (2): (10 Mark)

a) If you know that the total current density in any matter that has electric and magnetic properties can be written as: $\vec{J} = \vec{J}_f + \vec{J}_M + \vec{J}_P$, derive an expression for $\vec{J}_M$ and $\vec{J}_P$ and then derive the Maxwell-Ampère's law in matter. (7 points)

b) Given $\vec{E} = E_m \sin(\omega t - \beta z)\, \hat{j}$, find $\vec{D}$, $\vec{B}$ and $\vec{H}$. (3 points)

Question (3): (10 Mark)

a) Prove that $\vec{E} = -\vec{\nabla}V - \frac{\partial \vec{A}}{\partial t}$, where $\vec{E}$ is the electric field, V is the scalar potential and $\vec{A}$ is the vector potential. What is the physical meaning of this equation. (5 points)

b) Given Bio-Savart Law $\vec{B} = \frac{\mu_0}{4\pi} I \oint \frac{(d\vec{l}\times\hat{r})}{|\vec{r}|^2}$, find an expression for vector potential. (5 points)

Question (4): (10 Mark)

a) Derive Poynting vector in electrodynamics in its integral form and discuss the physical meaning of the Poynting theorem. (7 points)

b) In free space, $\vec{E} = 50 \cos(\omega t - \beta z)\, \hat{\imath}$ (V/m). Find the Poynting vector crossing a circular area of radius 2.5 m. (3 points)

Question (5): **(10 Mark)**

a) **Derive Poisson's equation under Lorentz gauge.** **(7 points)**

b) **Write the Lorentz transformation in terms of components that are parallel and perpendicular to the motion.** **(3 points)**

Question (6): **(10 Mark)**

a) **How electric and magnetic fields can transfer under Galilean transformation.**

(4 points)

b) **Prove that Maxwell's equation is not invariant under Galilean transformation.**

(6 points)

Useful relations:

For any two vectors $\vec{A}_1$ and $\vec{A}_2$:

- $\vec{\nabla} \cdot (\vec{A}_1 \times \vec{A}_2) = \vec{A}_2 \cdot (\vec{\nabla} \times \vec{A}_1) - \vec{A}_1 \cdot (\vec{\nabla} \times \vec{A}_2)$
- **Divergence theorem for vector $\vec{A}$ is:** $\int_S \vec{A} \cdot d\vec{a} = \int_V \vec{\nabla} \cdot \vec{A}\, d\tau$
- **Stokes's theorem for vector $\vec{A}$ is:** $\int_l \vec{A} \cdot d\vec{l} = \int_S (\vec{\nabla} \times \vec{A}) \cdot d\vec{a}$
- **Maxwell's Equations:** $\text{div}\, \vec{E} = \frac{\rho_c}{\varepsilon_0}$, $\text{div}\, \vec{B} = 0$, $\text{curl}\, \vec{E} = -\frac{\partial \vec{B}}{\partial t}$, $\text{curl}\, \vec{B} = \mu_0 \left(\vec{J} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t}\right)$

BEST WISHES **Instructor: Dr. Sherif Rashad MOKHTAR**

Assiut University Faculty of Science Physics Department		Level: Undergraduate Date:11.01.2018 Allowed time: 3 hours
Course code: P453	Course Title: NMR & Mossbauer spectroscopy	

Question (1): 15 points

Write short note on the following:

a) Relaxation in NMR.
b) Larmor Frequency.
c) Electric Quadrupole splitting.
d) Conditions for Mössbauer spectra.
e) Magnetic Imaging Resonance (MRI).

Question (2): 5 Points

Draw Energy level diagram illustrating magnetic splitting for 3/2 and 1/2 transitions in ^{57}Fe.

Question (3): 10 Points

Deduce an expression for spin-orbit interaction energy? Then apply this formula to calculate the fine structure of sodium atoms (3p state).

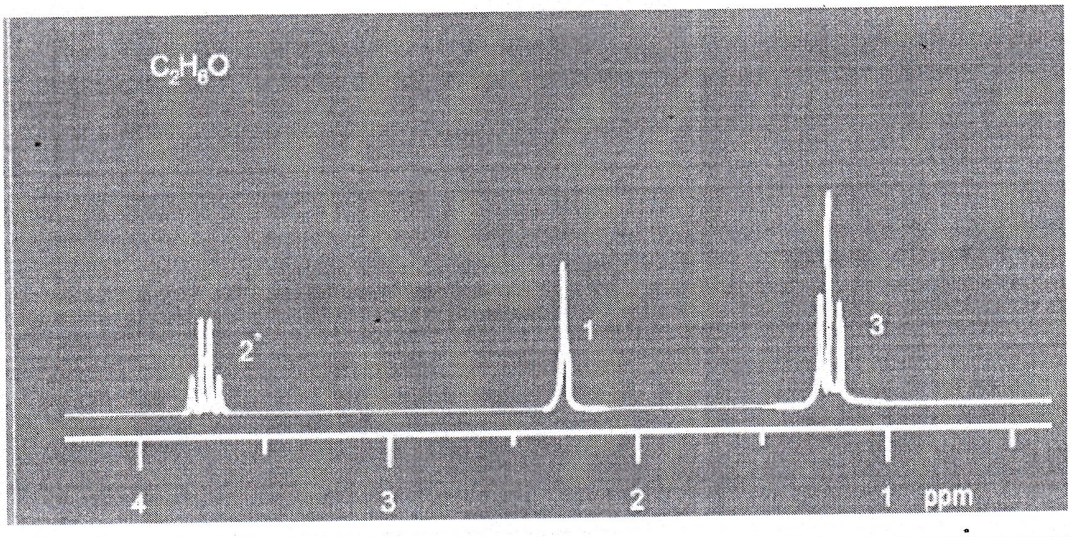
Question (4): 10 Points

Discuss in details Jahn-Teller effect? Does the spin system (high spin v. low spin) of a molecule play a role in Jahn-Teller Effects? Use diagrams to enhance your answer.

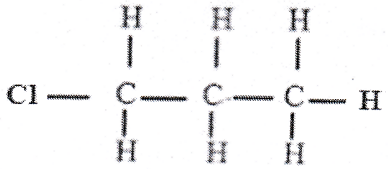
Answer only one of the following questions

Question (4): 10 Points

a) Provide a structure of a compound having a molecular formula C_2H_6O. Show your work and assign all relevant peaks in the figure below.



b) Predict NMR spectra for the following molecular formula C_3H_7Cl. Show your work and assign all relevant peaks in the figure below



Best Wishes

Assiut University Faculty of science Physics department	Semiconductor physics and thin films (451p)	Date: 13/1/2018 time: 3 hrs

Answer the following questions:

Question. 1: (10 deg.)

a) Explain in details the following:
- The determination of the minority carrier life time using AC photoconductivity measurements.
- Trapping and recombination processes of charge carriers in semiconductors.

b) The complex dielectric constant of nanostructured CdS semiconductor of particle size 3 nm is given by the relation:

$$\varepsilon^* = 12.5 + i6.2$$

at wavelength λ= 340 nm. Deduce the real part of refractive index (n), the absorption coefficient (α), the reflectivity (R) and the phase velocity (υ).

Question. 2: (10 deg.)

a) Drive an expression for:
- Holes concentration in an intrinsic semiconductor.
- Direct interband optical transitions (allowed and forbidden) in semiconductors.

b) Discuss briefly different types of exciton absorption process in semiconductors.

Question. 3: write accounts only on three of the following (10 deg.)

a) Light emitting diode.
b) Laser diode.
c) Photodiode and photoconductor.
d) Photo-voltaic cells

Question. 4: (10 deg.)

a) Explain luminescence phenomenon including the following:
- Thermoluminescence.
- Photo-luminescence.

b) Deduce an expression for Fermi level in n-type semiconductor at low temperature.

Question. 5: (10 deg.)

a) Write short accounts on different types of experimental techniques for thin films preparation.

b) Calculate the position of Fermi level and the conductivity at 400 K for germanium crystal containing 5×10^{23} arsenic atoms/m^3. Also, calculate the electrical conductivity if the mobility of electron is 0.39 $m^2 V^{-1}s^{-1}$.

With my best wishes

Prof. Dr. Mohamed A. Osman