University of Baghdad
College of Science
Department of Physics
Date: 13 / 8 / 2015

Qualifying Examination
for Ph.D Students
Year:2015-2016
Time: 3 Hours

الامتحان التنافسي للمتقدمين للدراسات العليا (الدكتوراه) لقسم الفيزياء-كلية العلوم جامعة بغداد للعام الدراسي ٢٠١٥-٢٠١٦

الاختصاص: فيزياء الليزر والجزيئية

اولاً:الورقة العامة ٢٠%

1-Multiple Choice Questions:

Q.1) The Coriolis force for dynamics of a particle in a rotating coordinate system is given as:

(a) $F = -m\dot{\omega} \times r$

(b) $F = -2m\omega \times \dot{r}$

(c) $F = -m\omega \times (\omega \times r)$

(d) $F = m\ddot{r}$

Q.2) Semiconductor nano crystals are classified as :

(a)1D (b) 0D (c) 3D (d) 2D

Q.3) The nature of binding for a crystal with alternate and evenly spaced positive and negative ions is:

(a) Ionic (b) metallic (c) covalent (d) Vander walls

Q.4) The characteristic impedance Z_o of free space encountered by electromagnetic wave has the SI units of

(a) Henry (b) Farad. Ohm (c) Ohm (d) $\frac{1}{Farad.Sec}$

Q.5) What is the quantum number n of a particle of mass m confined to a one dimensional box of length L when its energy is $2h^2 / mL^2$?

(a) 4 (b) 8 (c) 2 (d) 16

Q.6) Particles in degenerate energy levels all have the same

(a) Energy. (b) Momentum. (c) Quantum numbers. (d) Velocity.

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1-Multiple Choice Questions:

Q.7) The absolute value of the real number x is defined by:

(a) $|x| = \begin{cases} x, & if\ x < 0 \\ -x, & if\ x \geq 0 \end{cases}$, (b) $|x| = \begin{cases} x, & if\ x \geq 0 \\ -x, & if\ x < 0 \end{cases}$,

(c) $|x| = x$ for $-\infty < x < \infty$, (d) $|x| = -x$ for $-\infty < x < \infty$.

Q.8) The result of $\left(e^{x_1}\right)^{x_2}$ is given by:

(a) $e^{x_1+x_2}$, (b) e^{x_1/x_2}, (c) $e^{x_1-x_2}$, and (d) $e^{x_1 x_2}$.

Q.9) The Domain (D_0) and Range (R_g) of the function $y = \sqrt{x+4}$ are given by:

(a) $D_0: x \geq -4$, $R_g: y \geq 0$ (b) $D_0: -\infty < x < \infty$, $R_g: y = 0$

(c) $D_0: x = 0$, $R_g: y = -4$. (d) $D_0: x \geq -4$, $R_g: y = 0$.

Q.10) The energy operator in quantum mechanics, $\hat{H} = -\frac{\hbar^2}{2m}\frac{\partial^2 x}{\partial x^2} + V$

(here given for one particle in one dimension) is called the

a) Lagrangian b) Hamiltonian

c) Hermitian d) Angular momentum

Q.11) The commutator $\left[L^2, L_y\right] =$:

a) 0 b) $i\hbar L_x$ c) $-i\hbar L_z$

Q.12) The probability of finding a particle in differential region dx is:

a) $\psi(x,t)\,dx$ b) $\psi(x,t)/\psi^*(x,t)\,dx$ c) $\psi^*(x,t)\psi(x,t)\,dx$

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2- Short Note Questions:

Q.1) An ideal pendulum, its small-angle period is measured on the moon to be 0.4 second long. What must be the length of the pendulum arm? (Hint: assume that $m_{moon} = (1/6)\, m_{earth}$, exactly).

Q.2) A disk of mass M is constrained to roll down an inclined plane without slipping. Solve the Lagrange equations for motion.

Q.3) By plotting the temperature dependence of electrical resistivity, show how to differentiate between metal and semiconductor.

Q.4) There is no perfect solid due to the defects and dislocations , name them.

Q.5) Evaluate $\int \frac{\cos x\, dx}{\sin x}$.

Q.6) Find $\frac{dy}{dx}$ for $y = \cosh^2 5x - \sinh^2 5x$.

Q.7) Prove that : $H = \hbar w\left({}^{+}a\, a + \frac{1}{2}\right)$, where H is the Hamiltonian of the one dimensional harmonic oscillator, ${}^{+}a$ is the rising operator and a is the lowering operator.

Q.8) Hydrogen atom in the state $\psi(\vec{r}, t) = \sqrt{\frac{3}{4}}\psi_{100}(\vec{r})\, e^{-iE_1 t/\hbar} + \sqrt{\frac{1}{4}}\psi_{211}(\vec{r})\, e^{-iE_2/\hbar}$

What is the probability of measurements which give $E = E_2$?

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2 Multiple Choice Question:

Q.1) The moment of inertia for a tetrafluoromethane, CF_4, molecule. The C-F bond length in tetrafluoromethane is 1.315 Å. is:-

(a) 1.455×10^{-45} kg m^2 **(b)** 5.456×10^{-46} kg m^2 **(c)** 1.637×10^{-45} kg m^2 **(d)** 3.286×10^{-45} kg m^2

Q.2) The degeneracy of the rotational energy level with $J = 4$ for a heteronuclear diatomic molecule. Is: **(a)** 1 **(b)** 2 **(c)** 4 **(d)** 9

Q.3) Absorption of what type of electromagnetic radiation results in transitions among allowed rotational motions?

(a) radio waves **(b)** infrared light **(c)** ultraviolet light **(d)** X-rays E) microwaves

Q.4) The force constant for a Br-Br bond, given that the harmonic vibrational wavenumber of the $^{79}Br^{81}Br$ isotopomer of the bromine molecule is 323.2 cm^{-1},is :-

(a) 246 N m^{-1} **(b)** 984 N m^{-1} **(c)** 323 N m^{-1} **(d)** 107 N m^{-1}

Q.5) The rotational structure in the Raman spectrum of carbon dioxide, CO_2, is offset from the wavenumber of the incident radiation by 2.3622 cm^{-1}, 5.5118 cm^{-1}, 8.6614 cm^{-1}. The rotational constant of carbon dioxide is:-

(a) 0.3937 cm^{-1} **(b)** 1.1811 cm^{-1} **(c)** 0.5906 cm^{-1} **(d)** 2.3622 cm^{-1}

Q.6) The second harmonic generation of Nd:YAG laser is:

(a) Red light **(b)** green light **(c)** Blue light

Q.7) The wavelength of CO_2 laser occurred at.

(a) UV region **(b)** Visible region **(c)** IR region **(d)** Micro wave region

Q.8) The normal modes of vibrational are possible for a benzene molecule.is:-

(a) 6 **(b)** 30 **(c)** 12 **(d)** 31

Q.9) In tetragonal hybridization, p-orbitals are hybridized with s-orbital as in:

(a) C_2H_4 molecule **(b)** CH_4 molecule **(c)** C_2H_6 molecule **(d)** C_2H_2 molecule

Q.10) The atomic model that neglects the nuclei motion is:

(a) Born-Openheimer **(b)** Quantum model **(c)** Shell model **(d)** Bohr model

Q.11) For two fields interacting with an atom or molecule, it will be getting:

(a) single-photon process **(b)**Two-photon process **(c)**multiphoton process **(d)**None of them

Q.12) He-Ne laser is a :

(a) Solid laser **(b)** gas laser **(c)** semiconductor laser **(d)** liquid dye laser

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2 Short Note Questions

Q.1) Arrange the following regions of the electromagnetic spectrum in order of increasing energy: microwave, UV, visible, and IR.

Q.2) What wavenumber corresponds to the wavelength of 4μm?

Q.3) a-What is the different between laser and maser?

b-What is the different between fluorescent, phosphorescent, delay fluorescent?

Q.4) Define: Maser, Delay fluorescence, Spectrum, Spontaneous emission, Hot band?

Q.5) Compare between
1- Homogeneous broadening and inhomogeneous
2- Three level laser and four level laser.

Q.6) Find the relative population of two states at room temperature if $\Delta E=0.5eV$.

Q.7) For a tungsten lamp that works at temperature 2000°K and emission frequency 5×10^{14}Hz, find R?

Q.8) Find the divergence angle, if the wavelength for laser is 10.6μm and ω_0 equal to 3.6mm