

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  $Z_0$  of free space encountered by electromagnetic wave has the SI units of

(a) Henry

(b) Farad. Ohm

(c) Ohm

(d)  $\frac{1}{\text{Farad} \cdot \text{Sec}}$

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

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

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

(a)  $e^{x_1+x_2}$ , (b)  $e^{x_1/x_2}$ , (c)  $e^{x_1-x_2}$ , and (d)  $e^{x_1x_2}$ .

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

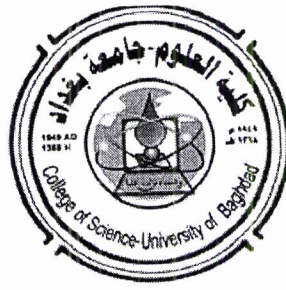
- a) Lagrangian      b) Hamiltonian  
c) Hermitian      d) Angular momentum

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

- 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)  $\psi^*(x,t)\psi(x,t) dx$

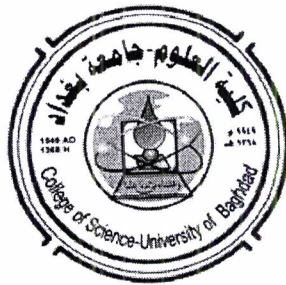


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**2- Short Note Questions:**

- 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  $m_{\text{moon}} = (1/6) m_{\text{earth}}$ , 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 :  $H = \hbar\omega \left( a^+ a + \frac{1}{2} \right)$ , 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  $E = E_2$ ?



## 2 Multiple Choice Question:

Q.1) The moment of inertia for a tetrafluoromethane,  $\text{CF}_4$ , molecule. The C-F bond length in tetrafluoromethane is 1.315 Å. is:-

- (a)  $1.455 \times 10^{-45} \text{ kg m}^2$  (b)  $5.456 \times 10^{-46} \text{ kg m}^2$  (c)  $1.637 \times 10^{-45} \text{ kg m}^2$  (d)  $3.286 \times 10^{-45} \text{ kg m}^2$

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  $^{79}\text{Br}^{81}\text{Br}$  isotopomer of the bromine molecule is  $323.2 \text{ cm}^{-1}$ , is :-

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

Q.5) The rotational structure in the Raman spectrum of carbon dioxide,  $\text{CO}_2$ , is offset from the wavenumber of the incident radiation by  $2.3622 \text{ cm}^{-1}$ ,  $5.5118 \text{ cm}^{-1}$ ,  $8.6614 \text{ cm}^{-1}$ . The rotational constant of carbon dioxide is:-

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

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  $\text{CO}_2$  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)  $\text{C}_2\text{H}_4$  molecule (b)  $\text{CH}_4$  molecule (c)  $\text{C}_2\text{H}_6$  molecule (d)  $\text{C}_2\text{H}_2$  molecule

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

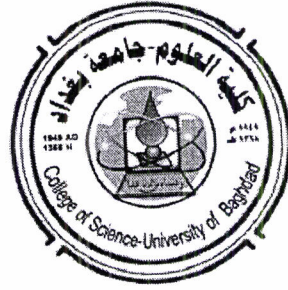
- (a) Born-Openheimer (b) Quantum model (c) Shell model (d) Bohr model

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  $4\mu\text{m}$ ?

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  $\Delta E = 0.5\text{eV}$ .

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

Q.8) Find the divergence angle, if the wavelength for laser is  $10.6\mu\text{m}$  and  $\omega_0$  equal to  $3.6\text{mm}$ .