Menofia University Faculty of Engineering Shebien El-kom Basic Engineering Sci. Department. Academic Year : 2016-2017 Date : 31 / 5 / 2017	Subject: Advanced Quantum Mechanics (1) Code: BES 706 Time Allowed: 3 hours Year : Master Total Marks: 100 Marks

Answer all the following questions: [100 Marks]

Q.1

(A) Define Quantum mechanics and some applications on it? [25]

(B) By using Lagrangian formulation find:

i) Equations of motion

ii) Momentum equation

iii) Force equation

(C) Derive Hamiltonian formulation from Lagrangian formulation then find the total variation of the Hamiltonian

Q.2

(A) Define Bloch-Floquet Waves? [25]

(B) The wave propagating periodic structure as shown Figure (1). By using $\varphi(k.x) = e^{ikx}u_p(x)$, find the solution of this wave.

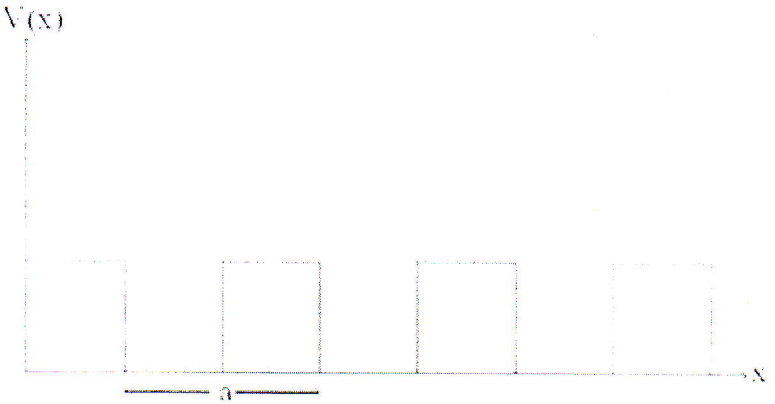

Figure 1: A 1D periodic structure of a potential profile for *V (x)* where a Bloch-Floquet wave can travel on it.

Q3 A non-relativistic particle of mass m is held in a circular orbit around the origin by an attractive force $f(r) = -k\,r$ where k is a positive constant [25]

i) Show that the potential energy can be written

$$U(r) = \frac{1}{2} kr^2$$

Assuming $U(r) = 0$ when $r = 0$

ii) Assuming the Bohr quantization of the angular momentum of the particle, show that the radius r of the orbit of the particle and speed v of the particle can be written

$$v^2 = \left(\frac{n\hbar}{m}\right)\left(\frac{k}{m}\right)^{0.5}, \qquad r^2 = \left(\frac{n\hbar}{k}\right)\left(\frac{k}{m}\right)^{0.5},$$

where n is an integer

iii) Hence, show that the total energy of the particle is

$$E_n = n\hbar\left(\frac{k}{m}\right)^{0.5}$$

iv) If $m = 3\times10^{-26}\ kg$ and $k = 1180\ N\ m^{-1}$, determine the wavelength of the photon in nm which will cause a transition between successive energy levels.

Q4 Consider the time-independent Schrodinger equation in three dimensions [25]

i) Write $\Psi(r.\theta.\emptyset) = \Psi_r(r)\ Y(\theta.\emptyset)$ as a separable solution and split Schrodinger's equation into two independent differential equations, one depending on r and the other depending on θ and ϕ.

ii) Further separate the angular equation into θ and ϕ parts

iii) Combine the angular part and the potential part of the radial equation and write them as an effective potential V_e. Then make the substitution $\chi(r) = r\ \Psi_r\ (r\ )$ and transform the radial equation into a form that resembles the one-dimensional Schrodinger equation.

This exam measures the following ILOs								
Question Number	Q1-a	Q1-b	Q3-b	Q4-a	Q1-c	Q2-a	Q3-a	Q4-c
	Q4-b				Q2-b	Q2-c	Q3-c	
	Knowledge &understanding skills				Intellectual Skills		Professional Skills	

With our best wishes

Dr. Ramzy M. Abumandour