# M.Sc. 1st Semester Examination, 2012
## PHYSICS

( *Quantum Mechanics* )

PAPER–PHS-102 (A + B)

*Full Marks* : 40

*Time* : 2 hours

*The figures in the right-hand margin indicate marks*

*Candidates are required to give their answers in their own words as far as practicable*

*Illustrate the answers wherever necessary*

**Use separate scripts for Gr.-A & B**

### GROUP – A

[ *Marks* : 20 ]

Answer **Q. No. 1** and any **one** from the rest

1.  Answer any *five* questions :                    2 × 5

    (a) A particle in the harmonic oscillator potential starts out in the state,

    $$\psi(x) = A\,[3\psi_0(x) + 4\psi_1(x)]$$

    Find $A$.

(b) Find $|\psi(x, t)|^2$ in prob. (a).

(c) Find $<x>$ in prob. (a).

(d) Find $<p>$ in prob. (a).

(e) Check that Ehrenfest's theorem holds for this wave function as described in prob. (a).

(f) Is the ground state of the infinite square well an eigen function of momentum ? If so, what is its momentum ? If not, why not ?

(g) The Hamiltonian for a certain two-level system is

$$\hat{H} = \epsilon \left[ |1><1| - |2><2| + |1><2| + |2><1| \right]$$

where $|1>$, $|2>$ is an orthonormal basis and $\epsilon$ is a number with the dimensions of energy. Find its eigen values.

(h) For hydrogen atom

$$\psi_{100} = \frac{1}{\sqrt{\pi a_B^3}} \, e^{-r/a}$$

Find $<x^2>$.

2. (a) A particle of mass $m$ is in the potential

$$V(x) = \infty \text{ for } x < 0$$
$$= -32\hbar^2/ma^2 \text{ for } 0 \le x \le a$$
$$= 0 \text{ for } x > a.$$

How many bound states are there ? Answer with necessary deduction. 5

(b) If

$$[\hat{A}, \hat{B}] = i\hat{C}$$

then prove the generalized uncertainty principle. i.e.

$$\sigma_A^2 \sigma_B^2 \ge \frac{1}{4} <\hat{C}>^2.$$

5

3. (a) For harmonic oscillator, prove that

$$[\hat{a}, \hat{a}^+] = 1.$$

Where $a^+ = \dfrac{1}{\sqrt{2\hbar mw}} (-ip + mwx)$

and its hermitian conjugate is $a$.

(b) If $V(r) = 0$ for $r < a$

$= \infty$ for $r > a$

Find the wave functions and the allowe energies.

(c) Show that the commutator of two Hermitia operators is anti-Hermitian.

GROUP – B

[ *Marks* : 20 ]

Answer Q. No. 1 & 2 and any one from the rest

1. Answer any *two* bits :

(a) Find the packing fraction of Diamond structur

    (b) Show that face centered tetragonal lattice does not exist.

    (c) Draw the variation of $B$ and $M$ with $H$ for a type-1 superconductor.

2. Answer any *two* bits :                   3 x 2

    (a) Explain with neat diagram the symmetry elements screw and glide.

    (b) Find the structure factor in terms of fractional coordinate.

    (c) Show that the inclusion of anharmonic interaction is necessary to understand the phenomenon of thermal expansion.

3. Derive Laue equation assuming scattering of X-ray by a crystal. Prove the equivalence of Laue equation and Bragg Diffraction condition.     8 + 2

4. (a) Derive London's equation and explain how its solution explain Meissner's Effect.

    (b) Prove that the monoatomic chain acts as a low pass mechanical filter.     (4 + 3)+ 3

-----