Mahindra University Hyderabad

École Centrale School of Engineering

End-semester Regular/Supplementary Examination, June 2023

UM

Program: B. Tech. Branch: All Year: I Semester: II

Subject: Physics (PH1201)

Date: 08-06-2023 **Start Time: 10.00 am**

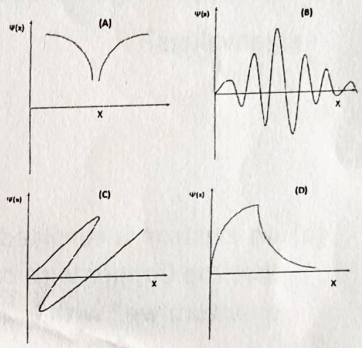
Time Duration: 3 Hours **Max. Marks: 100**

Instructions:

1) **All the questions are compulsory**
2) **Calculator is allowed**
3) **Values of useful constants are given at the end of the question paper.**

Q1. (7+7+6)

(a) See the (A), (B), (C), and (D) plots on the right side. Which of these wave functions cannot have physical significance in the interval shown? Why not?



(b) Write down Schrödinger's time-dependent and time-independent equation (steady state equation) for 1-D case. Comment on when we use the steady state equation.

(c) For a particle in a 1-D box of length L, sketch the wave functions and probability density for n=1, 2, 3 states.

Q2. (7+7+6)

(a) X-rays of wavelength 10.00 pm (1 pm = 10^{-12} m) are scattered from a target. Find the wavelength of x-rays scattered through 90 degree and 0 degree. At what angle of scattered x-rays, recoil electron will gain maximum kinetic energy?

(b) Ultraviolet light of wavelength 350 nm is directed at the potassium surface. Find the maximum kinetic energy of photoelectrons. Work function Ø of the potassium is 2.2 eV.

(c) Why wave nature of particles is not revealed in our daily experience? Explain in 2-3 sentences. Give an example where wave nature of particles is used.

(7+7+6)

Q3.

(a) A hydrogen atom is $0.5*10^{-10}$ m in radius. Use the uncertainty principle to estimate the minimum energy an electron can have in this atom. You can use non-relativistic calculations

(b) If a wavefunction is given by $\psi(x) = A(ax - x^2)$ for $0 \leq x \leq a$, calculated the value of A such that $\psi(x)$ is normalized.

(c) Is Sin(nx) an eigenfunction of the operator $\frac{d^2}{dx^2}$? If yes, what are the eigenvalues?

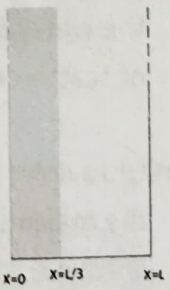
Q4. (10+10)

(a) An electron is confined to a 1nm thin Copper wire (1 nm = 10^{-9} m). Assuming that the Copper wire can be adequately described by a one-dimensional quantum well with infinite walls,

(i) Calculate the lowest possible energy for electron within the material in electron volt.

(ii) What is the minimum energy required to raise the electron from the ground state to first excited state? $m_e = 9.11 \times 10^{-31}$ kg

(b) Consider a particle in the ground state of an infinite square well potential with width L. Determine the probability P that the particle is confined to the first 1/3 of the width of the well, that is probability of finding the particle between x=0 to x=L/3.



Q5.

8+ (4x3)

(a) A H_2 molecule can be approximated by a simple harmonic oscillator with a spring constant $k = 1.1\times10^3$ N/m.
What are the quantized energy levels? Find the frequency of photons emitted when the H_2 molecule decays from the 2nd excited state to the 1st excited state.

(b) Choose the correct option for the following questions (b1 to b4):

(b1) For an infinite square well and a finite square well of the same length L, for each n, the quantized energy of the particle in a finite well are

A) The same as those for a particle in an infinite well

B) Lesser than those for a particle in an infinite well

C) Higher than those for a particle in an infinite well

D) Impossible to determine

(b2) A particle of energy $E = (\frac{32h^2}{mL^2})$ is trapped in a box of length L/2. This energy corresponds to a quantum number n of

A) 16

B) 8

C) 32

D) 4

(b3) A beam of electrons and a beam of protons (each particle has an energy of 6.5 eV), are incident separately on two identical barriers respectively each of 10.2 eV high and 10 A° wide. Which of the following is a CORRECT statement?

A) The electron will have greater transmission compared to proton.

B) The proton will have greater transmission compared to electron.

C) Both electron and proton will have equal tranmission probabilities.

D) Neither electron nor protons can cross the barrier.

(b4) The concept of tunneling is classically impossible because

A) the kinetic energy of the particle would be negative

B) the total energy of the particle would be negative

C) the total energy of the particle is equal to the kinetic and potential energies.

D) None of the above

Useful constants:

$c = 3 * 10^8 m/s$

$mass\ of\ electron = 9 * 10^{-31}\ kg$

$h = 6.6 * 10^{-34}$ J.s,

$\hbar = 1.1 * 10^{-34}$ J.s

mass of one hydrogen atom ~ mass of a proton = $1.67 * 10^{-27}\ kg$