King Fahd University of Petroleum and Minerals
Physics Department
Phys 212: Modern Physics
Second Exam
April 16,2002

Name :
ID#

You will have two hours (6.30-8.30). Please solve all the problems.

1. (20 points)

a. What was the basic postulate made by de Broglie?

b. How did de Broglie explained the quantization of the angular momentum in Bohr's theory?

c. Explain briefly (in words, no equations) the Davisson-Germer experimet, and mention the basic conclusion drawn out of this experiment.

d. Now we do some calculations. Assume that electrons accelerated through a potential difference V=54.0 V are scattered from a single-crystal sample at an angle of 50.0^{o} corresponding to n=1 diffraction maximum. Repeat the calculations made by Davisson and Germer to reach their conclusion.
(Take the spacing between the crystal layers to be 0.215 nm).

2. <u>(20 points)</u>

a. Explain the meaning of the uncertainty principle.
b. Estimate the minimum kinetic energy of a proton confined to a region of $\Delta x \sim 0.1$ nm.
c. A beam of electrons is incident on a slit of variable width. If it is possible to resolve a 1% difference in momentum, what slit width would be necessary to resolve the interference pattern of the electrons if their kinetic energy is
    i. 0.010 MeV
    ii. 1.0 Mev

3.(20 points)

A. Consider a particle confined to move in a one-dimensional box (infinite well) of width L ($0 < x < L$):

1. Write Schrodinger equation for the particle inside the box.
2. Solve Schrodinger equation to find the general solution.
3. Apply the boundary condition at x=0, to find the wavefunction.
4. Apply the boundary condition at x=L to show that the energy is given as

$$E_n = \frac{n^2\pi^2\hbar^2}{2mL^2}$$

B. Calculate the minimum speed of an atomic electron modeled as a particle in a box with width of 0.4 nm.

C. A laser emits light of wavelength 694.3 nm. If this light is due to transitions from the n=2 state to the n=1 state of an electron in a box, find the width of the box.

4. <u>(20 points)</u>

The wave function for the quantum oscillator in its ground state is given by

$$\Psi_0 = C_0 e^{-m\omega x^2 / 2\hbar}$$

a. Find the constant C_0
b. Find the expectation value of the position
c. Find the expectation value of the momentum

5.(20 points)

A.Two copper conducting wires are separated by an insulating oxide layer (CuO). Modeling the oxide layer as a square barrier of height 10.0 eV, estimate the transmission coefficient of penetration by 7.00-eV electrons if the layer thickness is 1.00 nm.

B. Transmission resonance occur when T=1 for particles with energy E > U. This only happen at certain energies. Express the resonance condition in terms of the particle energy using the formula given in the formula sheet.

CONSTANTS

Speed of light = 3×10^{8} meters per second

Avogadro's Number NA = 6×10^{23} particles/mole
(Remember, a mole is the molecular weight in grams, not kilograms)

Boltzmann's constant = 1.38×10^{-23} Joules/K

Planck's constant h = 6.626×10^{-34} Joule-sec

Electron mass = 9×10^{-31} kilograms

Proton mass = 1.67×10^{-27} kloigrams

Electron charge = 1.6×10^{-19} coulombs

Rydberg constant = 1.097×10^{7} /m