EXAMINATION III

Name: ____________________ UIN: ____________________

Time: 75 minutes
All problems are 5 points.

1. Which of the following is true about Bragg planes?
   a. They are evenly spaced panes within crystal structures of atoms.
   b. They are especially useful for detecting transitions between energy levels in the crystals' atoms.
   c. They are used to scatter alpha particles in gold and other materials.
   d. There is only one Bragg plane for any given crystal structure.
   e. All of the above.

2. X-rays of wavelength 0.207 nm are scattered from NaCl (d=0.282 nm). What are the angles **Θ** for the first and second order diffraction peaks.
   a. 10.1° 20.2°
   b. 15.7° 7.5°
   c. 21.3° 47.2°
   d. 40.1° 60.3°
   e. 5.3° 8.5°

3. Which of the following statements is most correct about the uncertainty principle?
   a. An electron with some momentum can be trapped into an arbitrarily small box.
   b. It is impossible to know exactly both the position and the momentum of a particle simultaneously.
   c. Our instruments will eventually be able to measure more precisely than the principle presently allows.
   d. On large length scales, the uncertainty principle dominates our understanding of the physical world.
   e. A particle limited in space can occupy any energy.

4. When de Broglie's matter waves are applied to the electron in the Bohr atom, which of the following occurs?
   a. De Broglie's results allow an integral number of wavelengths in the electron orbits.
   b. Bohr's quantization assumption for electron orbits is modified to incorporate the wave and spin properties of the electron.
   c. The electron is found to have in its orbit an add number of half-wavelengths.
   d. The angular momentum of the electron in the atom is constant, with longer wavelengths at larger quantum numbers.

5. Phase velocity is
   a. The maximum transverse velocity of a point on a wave, when the particle is moving fastest in each period of oscillation.
   b. Unrelated to the energy of the wave.
   c. Always half the group velocity in a wave packet.
   d. Always greater than the particle's velocity when the particle is described in terms of de Broglie matter waves.
   e. The velocity of a point on the wave at a given phase.

6. Compare the finite and infinite square well potentials and choose the correct statement.
   a. There is an infinite number of bound energy states for the infinite square well.
   b. There are bound states that fulfill the condition $E>V_o$ in the finite square well.
   c. There is an infinite number of bound energy states for the finite square well.
   d. The wave function penetrates into the region outside the infinite square well.
   e. The particle cannot be outside the finite square well.

7. Consider the harmonic oscillator and choose the correct statement.
   a. The energy levels have a separation of $(n+1/2)\,\hbar\omega$.
   b. The energy levels are farther apart the larger n is.
   c. The energy levels have a separation of $\hbar\omega$.
   d. The energy of the ground state is zero.
   e. The energies scale with n^2.

8. Which of the following states of the hydrogen atom is allowed?
   a. $n = 2,\ l = 2,\ m_l = 1$
   b. $n = 2,\ l = 2,\ m_l = 2$
   c. $n = 5,\ l = 2,\ m_l = 3$
   d. $n = 1,\ l = 0,\ m_l = 1$
   e. $n = 5,\ l = 2,\ m_l = 0$

9. Use the 3 quantum numbers (n, l, m_l) and choose the correct total degeneracy for the n = 5 state.
   a. 7
   b. 16
   c. 12
   d. 25
   e. 20

10. An electron is trapped in an infinite square well of width 0.7 nm. List the energies of the n = 1, 2, 3, 4 states.
   a. 0.511 eV, 2.49 eV, 4.51 eV, 8.33 eV
   b. 3.84 eV, 6.14 eV, 12.30 eV, 18.33 eV
   c. 0.11 eV, 0.44 eV, 9.99 eV, 16.81 eV
   d. 1.44 eV, 6.14 eV, 13.01 eV, 26.3 eV
   e. 0.767 eV, 3.07 eV, 6.91 eV, 12.27 eV

11. The lowest energy for a particle in a box has the value.
    a. $E_0 = 0$
    b. $E_1 = (n+\frac{1}{2})\hbar\omega$
    c. $E_0 = \frac{1}{2}\hbar\omega$
    d. $E_1 = \frac{3}{2}\hbar\omega$
    e. $E_1 = \frac{(\pi\hbar)^2}{2mL^2}$

12. In terms of the 4 quantum numbers n, l, m_l, m_s which cobinations describe valid wave functions and states?
    a. (5, 2, -1, -1/2)
    b. (4, 3, -1, -1/2)
    c. (5, 2, -3, -1/2)
    d. (5, 2, 3, -1/2)
    e. (4, 3, -2, +1/2)

13. Find the degeneracy of the second, third, fourth, and fifth levels for the three-dimensional cubical box.
    a. Not degenerate, 2 fold, 3 fold, 4 fold
    b. 3 fold, 3 fold, 2 fold, not degenerate
    c. 3 fold, 3 fold, 3 fold, not degenerate
    d. 3 fold, 3 fold, 3 fold, 3 fold
    e. 2 fold, 2 fold, 2 fold, not degenerate

14. List the letter codes for the sub shells in the sequence of increasing angular momentum.
    a. d, f, g, p, s
    b. s, p, d, f, g
    c. g, f, d, p, s
    d. p, d, s, f, g
    e. s, p, d, e, f

15. Which of the following does not result from applying the Schroedinger equation to the electron in the Hydrogen atom?
    a. Finding the Bohr radius.
    b. Finding the probability distribution functions for the electron in the Hydrogen atom.
    c. Deriving the correct energy level dependence.
    d. Finding the value of the intrinsic spin quantum number of the electron.
    e. Defining the rules restricting the quantum numbers n, l, and m_l.

16. Using the restrictions set forth by the uncertainty principle for which of the following combinations of values is it possible to know simultaneously?

I. $\vec{L}$
II. L
III. L_z
IV. L_x
V. L_y
VI. l
VII. m_l

a. II, III, VI, VII
b. I, III, VI, VII
c. III, IV, VI, VII
d. I, II, VI, VII
e. I, II, III, IV, V, VI, VII

17. Compute the de Broglie wavelength of
a 2000kg car travelling at 100 m/s,
a smoke particle of mass 10^{-6}g moving at 1 cm/s,
an electron with a kinetic energy of 1 eV,
a proton with a kinetic energy of 1 eV,
Select the proper result:
a. 3.3×10^{-41}m, 6.6×10^{-25}m, 1.2 nm, 0.3 nm
b. 3.3×10^{-25}m, 6.6×10^{-24}m, 1.2 nm, 0.3 nm
c. 3.3×10^{-39}m, 6.6×10^{-23}m, 12 Å, 0.028 nm
d. 5.5×10^{-25}m, 6.6×10^{-23}m, 12 Å, 500 Å

(note 1 Å= 10^{-10}m)

18. Stern and Gerlach performed an experiment that showed the space quantization of silver atoms in an inhomogeneous magnetic field. Their experiment demonstrated that
a. an additional spin angular momentum factor within the atom was causing the observed space quantization.
b. the number of m_l states was even, not governed by the factor $(2l + 1)$ as thought previously.
c. the differences in magnetic moment of the atom demonstrated space quantization in external magnetic fields.
d. space quantization is a property that only exists for energy levels, governed by the equantum number *n*.

e. the classically defined Bohr magneton was inaccurate because it did not take into account the space quantization of external magnetic fields within the atom.

19. The gyromagnetic ratio...
    a. is 1 for the magnetic moment associated with the spin and 2 for the magnetic moment associated with the angular momentum.
    b. relates the magnetic moments of spin and angular momentum to the total angular momentum.
    c. does not help explain the result of the Stern and Gerlach experiment.
    d. gives the values of intrinsic spin quantum number of the electron as 1/2 and -1/2.
    e. relates the Bohr magneton to the elementary charge.

20. Both the classical and quantum mechanical probability densities predict for a simple harmonic oscillator that
    a. the probability of the particle being at that location will be greatest at regions of greatest potential energy.
    b. the particle has a finite probability of being in a region with $V > E$ where E is the total energy of the system.
    c. the minimum energy of the oscillating particle is zero
    d. at very large values of n (the number of energy state), the particle will most likely be detected closest from the equilibrium position within its classically defined range of motion