General Physics II **Exam 5 - Chs. 27,28 - Quantum Physics** **April 27, 2009**

Name: Rec. Instr.: Rec. Time:

For full credit, make your work clear to the grader. Show the formulas you use, all the essential steps, and results with correct units and correct number of significant figures. Point values are given in parenthesis. For MC questions, choose the best answer. elementary charge $e = 1.602 \times 10^{-19}$ C, electron mass $m_e = 9.11 \times 10^{-31}$ kg, 1 electron-volt = 1.0 eV = 1.602×10^{-19} J, speed of light c = 2.9979 $\times 10^8$ m/s, Wien's Law $\lambda_p T = 2.90 \times 10^{-3}$ m·K, Planck's constant h = 6.626×10^{-34} J·s, $hc = 1240$ eV·nm.

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1. (2) Which type of electromagnetic radiation has the highest energy photons?

   a. radio waves. b. x-rays. c. γ-rays. d. visible light. e. ultraviolet light. f. all tie.

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2. (4) How large is the highest photon energy, in electron-volts, for visible light (400 nm to 700 nm)?

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3. (10) A laser is emitting light of wavelength 686 nm with a total power of 5.0 mW.

   a) (2) The color of the light is closest to a. red. b. green. c. blue. d. white.

   b) (6) How many photons per second does the laser pointer emit?

   c) (2) The laser shines on some unknown metal and does not produce photo-electrons. What could be adjusted so that photo-electrons are produced? Check all that apply.

   a. increase the laser power. b. increase the laser intensity.
   c. increase the laser wavelength. d. increase the laser frequency.

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4. (4) Three identical iron spheres are heated. The blackbody radiation from sphere A is strongest at a wavelength of 2.5 μm, from sphere B is strongest at 750 nm, and from sphere C is strongest at 125 nm.

   a) (2) Which sphere is at the lowest temperature?

   a. A. b. B. c. C.

   b) (2) What is the ratio of sphere temperatures, T_C/T_A?

   a. 0.025 b. 0.05 c. 10. d. 20. e. 400.

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5. (3) Which of these is evidence for particle-like behavior of light? Check all that apply.

   a. single-slit diffraction. b. Compton scattering of light by an electron.
   c. refraction of light. d. light passing through a prism can form a rainbow pattern.
   e. the photoelectric effect. f. thin film interference.

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6. (3) Which of these is evidence for wave-like behavior of electrons? Check all that apply.

   a. black-body radiation. b. Compton scattering of light by an electron.
   c. quantized Bohr orbitals. d. electron motion in cathode ray tubes.
   e. the photoelectric effect. f. electron diffraction by crystals.

7. (10) In a photoelectric effect experiment, it is found that metal X (an unknown) produces photo-electrons only if exposed to light of wavelength less than 380 nm.

a) (4) Calculate the work function of this metal, in eV.

Now light at wavelength 240 nm shines on metal X.

b) (4) What is the maximum kinetic energy, in eV, of the photo-electrons that are being produced?

c) (2) What stopping potential, in volts, would prevent the flow of the photo-current?

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8. (2) Which of these has the largest de Broglie wavelength? (KE is kinetic energy.)

a. an electron with KE = 5 eV. b. a proton with KE = 5 eV.
c. an electron with KE= 5 keV. d. a proton with KE = 5 keV.

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9. (6) An electron ($m = 9.11 \times 10^{-31}$ kg) has been accelerated through a potential difference of 5.0 kV. Calculate its de Broglie wavelength.

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10. (4) The wavelength of a photon is the same as the de Broglie wavelength of an electron ($\lambda = 500$ nm).

a) (2) Which has the larger momentum?

a. the photon. b. the electron. c. it's a tie.

b) (2) Which has the larger energy?

a. the photon. b. the electron. c. it's a tie.

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11. (3) Which of these will cause the de Broglie wavelength, in general, to get larger? Check all that apply.

a. increase the mass. b. increase the speed. c. increase the kinetic energy.
d. decrease the mass. e. decrease the speed. f. decrease the kinetic energy.

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12. (12) Decide whether these statements about the Bohr atomic model are true or false.

a. **T** **F** It (the Bohr model) gives quantized atomic energy levels.

b. **T** **F** It predicts a continuous spectrum of emitted light from atoms.

c. **T** **F** It explains the similarities between emission and absorption spectra.

d. **T** **F** It assumes well-defined circular electron orbits.

e. **T** **F** It works only for atoms or ions with one electron.

f. **T** **F** It predicts changes in the emission spectrum due to an applied magnetic field.

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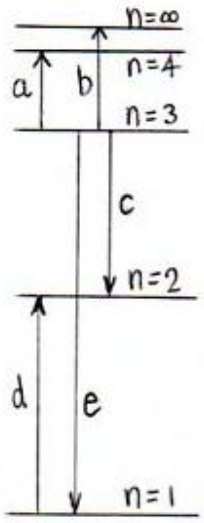
13. (10) The arrows on the diagram show some transitions that a hydrogen atom can make between energy levels, according to the Bohr model. Of the transitions shown,



a) (2) Which transitions correspond to **emission** of radiation by the atom?

b) (2) Which transitions corresponds to **absorption** of radiation by the atom?

c) (6) For only the transitions shown, calculate the shortest wavelength *emitted*.

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14. (4) A hydrogen atom is in the $n = 2$ state. What energy photon could it absorb that would ionize the atom, and give the ejected electron 25.0 eV of kinetic energy? (Find the photon energy in eV.)

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15. (4) For a Li^{2+} ion in its ground state, according to the Bohr model, what is the lowest energy photon that it could absorb? Give the answer in eV.

16. (4) In an experiment, ultraviolet light at 55 nm is used to measure the position of an electron. Because the photon exchanges momentum with the electron, what is the approximate uncertainty Δv in the electron's speed, caused by the measurement?

17. (2) Which aspect of electromagnetic waves is most like the squared wavefunction $|\Psi|^2$ for quantum waves?

a. frequency. b. wavelength. c. intensity. . d. speed.

18. (2) In wave mechanics (i.e. quantum mechanics), which quantity determines the probability distribution for an electron?

a. frequency. b. wavelength. c. energy. . d. Ψ. e. $|\Psi|^2$.

19. (2) **T F** The quantum theory (of Heisenberg and Schrodinger) is better than classical physics because it predicts exactly where an electron will be in the future.

20. (2) **T F** The quantum theory explains the splitting of spectral lines of hydrogen in a magnetic field.

21. (6) The highest atomic subshells for cobalt (Co) in its ground state have the configuration $3d^7 4s^2$.

a) (2) What is the value of the orbital quantum number l in the 3d subshell?

a. 0 b. 1 c. 2 d. 3 e. 4

b) (2) What is the maximum number of electrons that could occupy the 3d subshell?

c) (2) Which diagram shows how the 3d electron spins line up (m_s values) in the ground state of cobalt?

a. ↑↑↑↑↑↑↑ b. ↑↑↑↑↑↑↓ c. ↑↑↑↑↑↓↓ d. ↑↑↑↑↓↓↓

22. (2) Generally, for any atom, which of these electron configurations is not allowed? Check all that apply.

a. $1s^2 2s^2 2p^3$ b. $1s^2 2s^2 3p^3$ c. $1s^2 2s^2 2d^3$ d. $1s^2 2s^1 2p^1$ e. $1s^2 2s^1 2p^7$

23. (2) Into how many different energy levels might the 3d subshell be split when a magnetic field is applied ("Zeeman effect")?

a. 2 b. 3 c. 4 d. 5 e. 7 f. 10

24. (2) Which of the following outer subshell configurations would correspond to a nobel gas? Check all that apply.

a. $2s^2$ b. $2p^2$ c. $2p^5$ d. $4p^6$ e. $3d^{10}$

25. (2) Which of the following outer subshell configurations would correspond to a halogen? Check all that apply.

a. $2s^2$ b. $2p^2$ c. $2p^5$ d. $4p^6$ e. $3d^9$