

PHYSICS 6

HOUR EXAM 2

SPRING 2003

NAME _____

This is a closed book, closed notes exam, except for a copy of Copenhagen. You may use calculators.

Make sure you show all your work! You will get partial credit for correct intermediate steps.

Useful data and equations:

Binomial distribution for k identical objects out of n choices (e.g. k heads in n tosses):

$n! / ((n-k)!k!) \cdot (p)^k(1-p)^{n-k}$ where p is the probability for a single one of the k's (e.g. head)
 speed or velocity = $v = \text{distance} / \text{time}$

Force = mass \cdot acceleration Work = force \cdot distance Power = Energy / time

Momentum = $p = m v$ ($m = \text{mass}$)

Kinetic Energy = $1/2 m v^2$

$c = \lambda f$ where λ is wavelength, f is frequency

Photon $E = h f$ deBroglie: $\lambda = h / p$

Bohr model: $E_n = (-13.6 \text{ eV}) / n^2$

Heisenberg's Uncertainty $\Delta x \Delta p \geq h / 4\pi$

Constants: Avogadro's Number: $N_0 = 6.0 \times 10^{23}$

Velocity of light: $c = 3 \times 10^8$ meter/sec

Planck's constant $h = 6.6 \times 10^{-34} \text{ J}\cdot\text{s}$ **or** $h = 4.1 \times 10^{-15} \text{ eV}\cdot\text{s}$

Units: Mass: 1 Kilogram Energy: 1 J(oule) = 1 Kg $\text{m}^2 / \text{sec}^2$;

1 electron Volt (eV) = $1.6 \times 10^{-19} \text{ J}$

Power: 1 Watt = 1 J/s

Grades: points /possible points

I	/60	(multiple choice)
II	/20	
III	/30	
IV	/10	
V	/60	(essay)
Total:	/180	

NAME _____

I. Multiple choice -- circle the **one best answer**. 10 points each.

- 1) Which of the following is **NOT** true of Bohr's model of the atom?
 - a. Photons exist.
 - b. Atoms radiate discrete Electromagnetic energies only.
 - c. Electrons are in discrete, quantized orbits only.
 - d. Electrons behave like waves and particles simultaneously.
 - e. Electrons behave like particles.

- 2) Einstein's explanation of the Photoelectric effect introduced the new notion that
 - a. photons exist and have a continuum of possible energies like EM waves.
 - b. photons exist and have discrete amounts of possible energies, unlike EM waves.
 - c. peak wavelength increases with temperature.
 - d. molecules radiate a continuum of Electromagnetic energies.
 - e. electrons can behave like waves.

- 3) Schrödinger's equation for the Hydrogen atom determines
 - a. that the bound electron can have a continuum of energies.
 - b. the exact orbit of the electron at any time, given some initial values.
 - c. a set of $\Psi(\mathbf{x},t)$ functions or states for the electron.
 - d. $\Psi(\mathbf{x},t)$ functions or states for the nucleus.
 - e. when the electron will emit a photon.

- 4) In explaining the motion of a particle, which statement is true about Quantum Mechanics?
 - a. The $\Psi(\mathbf{x},t)$ function has a value throughout the space available, like a wave.
 - b. The $\Psi(\mathbf{x},t)$ function predicts the same path as a classical particle.
 - c. The $\Psi(\mathbf{x},t)$ function is the probability for the particle to fill the space.
 - d. $|\Psi(\mathbf{x},t)|^2$ is the probability for the particle to follow the same path as classical particle.
 - e. In passing through a double slit apparatus, the particle acts like a classical "lump" or bullet (in Feynman's sense).

- 5) Which of the following is NOT among the consequences of Quantum Mechanics and the Copenhagen Interpretation
- Energy conservation can be violated for very short time intervals.
 - Particles can penetrate through classically impenetrable barriers.
 - The most that can be predicted about where a system will be at a particular time is its probability to be there.
 - Where a system will be at a particular time can be known with certainty.
 - A cat locked in a box with a random, lethal gas release can be in a mixed state of alive and dead.
- 6) In the play Copenhagen Bohr and Heisenberg talk about their meeting in 1941. At the time of that meeting, according to the play and history,
- Niels Bohr was working on the Manhattan Project.
 - Heisenberg's group had developed a nuclear bomb.
 - US and allies had developed a nuclear bomb.
 - Heisenberg may have grossly overestimated the critical mass of Uranium.
 - Bohr knew the critical mass of Uranium, but didn't reveal it to Heisenberg.

II. A hydrogen atom undergoes a transition from the $n=4$ to the $n=2$ state.

You may need h in units of $\text{eV}\cdot\text{s}$ $h = 4.1 \times 10^{-15} \text{ eV}\cdot\text{s}$

a. What is the energy of the photon emitted? Use units of eV .

b. What is the frequency of that photon?

Name_____

V. Choose one of these topics from the play Copenhagen to write a one page essay. Make sure you refer to specific incidents or sections of the play to support your conclusions.

- a) How does Quantum Mechanics put humans back at the center of universe?
- b) How are the Probability States of atoms illustrated via Bohr walking around in Copenhagen?
- c) How do Heisenberg's motives for meeting with Bohr in 1941 compare with a 2-slit (or more) experiment?

Name _____