**MODERN PHYSICS** **PRACTICE FINAL EXAM**

NAME:_____

Write your name. Your test will not be graded without your name written.
Write your answer on the line provided for each question!!

1. An elementary particle is moving from the upper atmosphere toward the surface of the Earth at a speed of 0.999978 c. Take that the height of the atmosphere in the reference frame of the Earth is 100 km. Then, the apparent height of the atmosphere in the reference frame of the particle is about

___ A) 6.5 km B) 469 m C) 0.660m D) 4.1 km E) 663m

2. A rocket ship of rest length 100 m is moving at speed 0.8 c past a timing device that records the time interval between the passage of the front and back ends of the ship. This time interval is:

___ A) 0.20 μs B) 0.25 μs C) 0.33 μs D) 0.52 μs E) 0.69 μs

3. A particle of rest mass $m_0$ moves at a speed 0.80 c with respect to a rest frame. Its mass, as measured in the rest frame, is

___ A) 0.80 $m_0$ B) $m_0$ C) 1.67 $m_0$ D) 0.33 $m_0$ E) 0.25 $m_0$

4. How much is the momentum of a proton moving at a speed of v = 0.76 c?

___ A) $3.8 \times 10^{-19}$ kg·m/s B) $5.8 \times 10^{-19}$ kg·m/s C) $1.7 \times 10^{-10}$ kg·m/s D) $2.6 \times 10^{-27}$ kg·m/s E) $7.8 \times 10^{-19}$ kg·m/s

5. A distant star is radiating heat and light at the rate of $3.9 \times 10^{26}$ W. At what rate is the star losing mass due to this release of energy?

___ A) $6.2 \times 10^{7}$ kg/s B) $1.4 \times 10^{8}$ kg/s C) $4.3 \times 10^{9}$ kg/s D) $3.9 \times 10^{26}$ kg/s E) To solve, one must know the frequency of radiation and the speed of the star.

6. The work function of metal 1 is $\Phi_1$ and that of metal 2 is $\Phi_2 = 2 \cdot \Phi_1$. The ratio of the corresponding threshold wavelengths, $\lambda_{01}/\lambda_{02}$, is:

___ A) 0.5·h B) 2·h C) 0.5 D) 2 E) Not enough information to solve the problem

7. When x-rays scatter from free electrons, the x-ray's

I) wavelength is conserved.
II) momentum is conserved.
III) energy is conserved.

Which of the above is correct?

___ A) I, II, and III B) I and II C) III only D) II & III E) none

8. A photon in light beam A has twice the energy of a photon in light beam B. The ratio $p_A/p_B$ of their momenta is:

___ A) 1/2 B) 1/4 C) 1 D) 2 E) 4

9. Which of the following is a <u>correct</u> statement:

A) To say that an electron moves with a certain de Broglie wavelength, means that the electron moves back and forth at that wavelength.

___ B) It is possible to have the group velocity larger than the speed of light, only if the phase velocity is larger than the speed of light.

C) $\psi(x) = 5 \sin(kx)$, for $0 \leq x \leq \pi/2$, cannot be a solution of the Schrödinger equation.

D) A Bohr atom violates the Heisenberg's Uncertainty Relationship for position and momentum.

E) In order to tunnel through a potential barrier a particle must have a wavelength longer than the barrier width.

10. Photons are scattering from stationary free electrons. The largest change in wavelength that can occur is:

A) $2.43 \times 10^{-12}$ m B) $4.85 \times 10^{-12}$ m C) $2.43 \times 10^{-9}$ m

____ D) $4.85 \times 10^{-9}$ m E) dependent on the frequency of the incident light

11. If the difference between energy levels n = 7 to n = 5 of a harmonic oscillator is $5.9 \cdot 10^{-18}$ J, the angular frequency ω (in rad/s) is about:

____ A) $1.1 \times 10^{17}$ B) $2.8 \cdot 10^{16}$ C) $5.6 \times 10^{16}$ D) $1.4 \times 10^{16}$

12. The longest wavelength of the Paschen series corresponds to the following transition:

A) from n = 3 to n = 2 B) from n = 3 to n = 1 C) from n = ∞ to n = 3

___ D) from n = 4 to n = 3 E) from n = 3 to n = ∞

13. An electron in an atom initially has an energy 7.5 eV above the ground state energy. It drops to a state with an energy of 3.2 eV above the ground state energy and emits a photon in the process. The momentum of the photon is approximately:

A) $1.4 \times 10^{-8}$ kg·m/s B) $2.3 \times 10^{-27}$ kg·m/s C) $3.4 \times 10^{-19}$ kg·m/s

___ D) $1.1 \times 10^{-24}$ kg·m/s E) Cannot be determined from the information given.

14. Of the following sets of quantum numbers for an electron in a hydrogen atom, which is possible?

A) n = 5, l = 3, $m_l$ = -3 B) n = 3, l = 3, $m_l$ = -2 C) n = 5, l = -3, $m_l$ = 2
___ D) n = 3, l = 2, $m_l$ = -3 E) n = 4, l = 5, $m_l$ = -2

15. The lifetime of a certain excited state in an atom is about $1.5\times10^{-8}$ s, i.e., the electron takes about $1.5\times10^{-8}$ s to emit a photon and complete the transition to a lower state. What is the energy uncertainty of such an excited state?

A) $1.4\times10^{-7}$ J B) $4.9\times10^{-24}$ J C) $3.5\times10^{-27}$ J
____ D) $2.2\times10^{-8}$ J E) $2.2\times10^{-26}$ J

16. An electron is confined within a length of $10^{-10}$ m. The uncertainty in the electron's speed is about:

A) zero B) $10^{10}$ m/s C) $6.6\times10^{-29}$ m/s
___ D) $7.3\times10^{6}$ m/s E) $5.5 \times 10^{5} m/s$

17. The group velocity of the de Broglie waves, associated with a body whose angular frequency depends on the wave number as

$$\omega = 3k^2$$

is equal to

___ A) $1/\lambda$ B) 3k C) 6k D) $\omega/k$ E) $3k^2$

18. A hydrogen atom is in its second excited state, i.e., two states above the ground state. Its energy in this state is -1.51 eV. What is the longest wavelength which will be able to ionize this excited atom?

A) 1.41 nm B) 31.4 nm C) $4.1\times10^{2}$ nm
___ D) $8.21\times10^{2}$ nm E) $7.4\times10^{4}$ nm

19. X-rays with an initial wavelength of 0.0824 nm scatter from free electrons at an angle of $90^0$. The new wavelength is

A) 0.0800 nm B) 0.0824 nm C) 0.0848 nm
___ D) 0.0024 nm E) 0.0776 nm

20. An electron moves in the x direction. We can measure its speed to a precision of 1%. We can say the following about the electron's motion in the y direction:

A) The electron's y coordinate is known to a precision of 1%.
B) The electron's velocity component $v_y$ is known to a precision of 1%.
____ C) The electron's y coordinate is known to a precision of $\hbar/\Delta x$.
D) The electron's velocity component $v_y$ is known to a precision of 100%.

21. The ground state energy of a proton in a one-dimensional infinite potential well is 4 eV. If the width of the well is doubled, the ground state energy will be about:

____ A) 1 eV B) 2 eV C) 4 eV D) 8 eV

22. The de Broglie wavelength associated with a proton of kinetic energy 2.6 eV is about:

A) $3.0\times10^{-10}$ m B) $1.8\times10^{-11}$ m C) $7.6\times10^{-10}$ m

___ D) $7.1\times10^{-21}$ m E) $1.6\times10^{-15}$ m

23. How many different states exist in the hydrogen atom for an electron in the shell specified by the quantum numbers n = 2 and $l$ = 1 ?

___ A) 4 B) 6 C) 2 D) 8

24. A collection of hydrogen atoms in the first excited state is illuminated with ultraviolet light of wavelength 59.0 nm. The kinetic energy of the emitted electrons is about:

___ A) 7.40 eV B) 21.0 eV C) 13.6 eV D) 17.6 eV E) 3.37 eV

25. At one instant of time the wavefunction of a particle is

$$\psi(x) = A \cdot e^{-b|x|}, \quad \text{for} -\infty < x < +\infty$$

Constant A is given by:

___ A) 0 B) $\sqrt{b}$ C) $\frac{1}{\sqrt{b}}$ D) $\frac{1}{b}$ E) b

26. Which of the following processes can occur in an atom in its ground state?

I) emission II) absorption

___ A) I only B) II only C) I & II D) neither I nor II

27. A system consists of two particles with masses $2m_e$ and $4m_e$, where $m_e$ is the mass of an electron. The reduced mass of the system is:

___ A) $6m_e$ B) $4m_e/3$ C) $2m_e$ D) $3m_e/4$

28. The frequency of a wave described with a formula y = 3·sin (4t - 5x) is about

___ A) 0.64 B) 5 C) 25 D) 4 E) 1.3

29. A proton is trapped in an infinite one-dimensional well of width 0.132 nm. The proton is in the n = 10 state. The energy of the proton is about:

___ A) 46.5 eV B) 1.18 eV C) 0.12 eV D) 85.2 keV E) 2160 eV

30. The ground state energy of a harmonically oscillating electron is 1.24 eV. The energy that must be added to the electron to move it to the fourth excited state is:

___ A) 0.390 eV B) 0.696 eV C) 9.92 eV D) 4.96 eV E) 2.48 eV