Physics 107: Ideas of Modern Physics

Exam 3
Apr. 18, 2007

Name______________________________________________________
ID #_________________________               Section #______________

On the Scantron sheet,
1) Fill in your name
2) Fill in your student ID # (not your social security #)
3) Fill in your section # (under ABC of special codes)

Fundamental constants:
\[c = \text{speed of light} = 3 \times 10^8 \text{ m/s}\]
\[g = \text{accel. of gravity on Earth} = 10 \text{ m/s}^2\]
\[G = \text{gravitational constant} = 6.7 \times 10^{-11} \text{ N-m}^2/\text{kg}^2\]

Photon energy \(E = \frac{hc}{\lambda} = 1240 \text{ eV-nm/} \lambda\)
1. The brightness of a beam of light is increased, but the color remains the same. The behavior of the energy and wavelength of each photon in the beam is described as

a. Photon energy unchanged, wavelength decreases
b. Photon energy decreases, wavelength decreases
c. Photon energy increases, wavelength increases
d. Photon energy increases, wavelength decreases
e. Photon energy unchanged, wavelength unchanged

3. A scientist is trying to eject electrons from a metal by shining a light on it. The electrons are bound inside the metal need an energy of 2.0 eV to escape. Which wavelength will eject electrons?

a. any of these
b. 600 nm
c. 350 nm
d. 420 nm
e. none of these

4. A beta particle, an alpha particle and a neutron all have the same momentum. Which has the longest wavelength?

a. beta particle.
b. depends on kinetic energy.
c. all the same.
d. alpha particle.
e. neutron.

5. Particular red (600 nm) and blue (200 nm) lasers both have the same power output (Joules/sec). How does the number of photons per second coming out of each laser compare?

a. Blue has 9 times photons/sec as red.
b. Blue has 3 times photons/sec as red.
c. Blue has 1/3 the photons/sec as red.
d. Blue has 1/9 the photons/sec as red.
e. Both the same.
6. A quantum particle in a box is in the lowest energy (ground) state. If the size of the box is increased, the wavelength and energy of the particle change as

a. wavelength shorter, energy smaller  
b. wavelength longer, energy smaller  
c. wavelength shorter, energy larger  
d. wavelength and energy unchanged  
e. wavelength longer, energy larger  

7. A typical x-ray photon used in a dentist’s office to produce an x-ray of your teeth has an energy of 40,000 eV. Its wavelength is about

a. 3 nm  
b. 0.03 nm  
c. 300 nm  
d. 30 nm  
e. 0.3 nm  

8. A hydrogen atom has quantum states with energies \(-13.6eV/n^2\). What is the wavelength of the photon emitted when it makes a transition from the \(n=3\) state to the \(n=2\) state?

a. 365 nm  
b. 820 nm  
c. 1.9 nm  
d. 650 nm  
e. 70 nm  

9. A particle in a box has quantum states with energies \(E= E_0n^2\) with \(n=1,2,3,4\ldots\) and \(E_0=0.5\ eV\). Which of these photons could in principle be absorbed?

a. 3 eV  
b. 2.5 eV  
c. 2 eV  
d. 1 eV  
e. 0.5 eV
10. The energy levels of a hydrogen atom are given by \( E = -\frac{13.6}{n^2} \text{ eV} \), as shown:

Light with a continuous range of wavelengths from 450 nm to 700 nm is shined on the atom. All the light passes by the atom except particular energies that are absorbed by the atom, leaving black ‘absorption lines’ in the spectrum. How many absorption lines are seen?

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

11. An electron is confined to a box of length \( L \). It is in the lowest energy (ground state), determined by exactly \( \frac{1}{2} \) wavelength of the electron matter-wave fitting in the length of the box. The sides of the box are now pushed in to make the length smaller. The electron energy and wavelength

a. Energy same, wavelength decrease  
b. Energy decrease, wavelength increase.  
c. Energy increase, wavelength decrease.  
d. Energy increase, wavelength increase.  
e. Energy decrease, wavelength decrease.

12. Here is the first excited state wavefunction for a particle in a box. Compare the probabilities (\( P \)) of finding the particle at the indicated locations.

a. the probabilities are uncertain  
b. \( P(0.25 \text{ nm}) < P(0.75 \text{ nm}) \)  
c. \( P(0.25 \text{ nm}) = P(0.75 \text{ nm}) \)  
d. \( P(0.25 \text{ nm}) > P(0.75 \text{ nm}) \)  
e. need to know mass of particle

13. The strong force acts between which of the following particles in an atom? (nucleon = proton or neutron)

a. between protons and electrons only  
b. between a proton and a neutron only  
c. between neutrons only  
d. between protons only  
e. between all nucleons
14. Below are three wavefunctions for a particle in a box. Which has the highest energy?

a. B  
b. C  
c. B and C equal and highest  
d. A and B equal and highest  
e. A

15. $^{15}\text{C}$ is an extremely unstable isotope of carbon. It has 6 protons and 9 neutrons in its nucleus. It decays by emitting an electron. After the decay, it becomes

a. $^{16}\text{B}$  
b. $^{15}\text{C}$  
c. $^{14}\text{C}$  
d. $^{15}\text{N}$  
e. $^{14}\text{N}$

B is the element with 5 protons  
C is the element with 6 protons  
N is the element with 7 protons

16. A fossil bone has a $^{14}\text{C} : ^{12}\text{C}$ ratio that is 1/4 of the $^{14}\text{C} : ^{12}\text{C}$ ratio in the bone of a living animal. What is the approximate age of the fossil? ($^{14}\text{C}$ half-life is 5,730 years).

a. 17,190 years  
b. 11,460 years  
c. 91,680 years  
d. 45,840 years  
e. 22,920 years

17. Excited $^{234}\text{U}$ has 92 protons and 234 nucleons total in its nucleus. It decays by emitting a gamma particle. After the decay, it is

a. $^{234}\text{U}$  
b. $^{234}\text{Th}$  
c. $^{230}\text{Ra}$  
d. $^{230}\text{Th}$  
e. $^{232}\text{Pa}$

U is the element with 92 electrons  
Pa is the element with 91 electrons  
Ra is the element with 88 electrons
18. A particular radioactive nucleus has 16 protons and 12 neutrons in the nucleus. The particle it emits when it decays is likely to be

a. a gamma particle  
   b. an alpha particle  
   c. an electron  
   d. a positron  
   e. a neutron

19. The Heisenberg uncertainty principle is best summarized as

a. the deBroglie wavelength is inversely proportional to the momentum  
   b. radioactive decay is a random event  
   c. the probability of finding a quantum particle is uncertain  
   d. the position and momentum of a particle cannot both be known exactly  
   e. all quantum particles have spin

20. Which of the following is the probability of finding a quantum particle at a particular spatial location?

a. Energy  
   b. $\sqrt{|\text{Wavefunction}|}$  
   c. $(\text{Wavefunction})^2$  
   d. Wavefunction  
   e. Momentum

21. An isotope of an atom is one that has

a. Equal number of protons and neutrons.  
   b. Different number of neutrons.  
   c. Different number of protons.  
   d. Different number of electrons  
   e. Equal number of neutrons and electrons.