Physics 107:
Ideas of Modern Physics

Exam 3
Nov. 29, 2006

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*= speed of light = 3×10^8 m/s
g= accel. of gravity on Earth = 10 m/s^2
G= gravitational constant = 6.7×10^{-11} N-m^2/kg^2

Photon energy $E = hc/\lambda = 1240$ eV-nm/λ

1. A

2 According to Einstein, increasing the brightness of a beam of light without changing its color will increase

a. the number of photons per second
b. the energy of each photon
c. the photon speed
d. the frequency of each photon
e. the wavelength of each photon

3. A scientist is trying to eject electrons from a metal by shining a light on it. The electrons are bound inside the metal by an energy of 4.2 eV. Which wavelength will eject electrons?

a. 640 nm
b. 420 nm
c. 350 nm
d. any of these
e. none of these

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

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

5. Particular red (600 nm) and blue (300 nm) lasers both shoot out the same number of photons per second. How does the **power output** of the two lasers compare?

a. Both the same.
b. Blue has 1/4 the power as red.
c. Blue has 1/2 the power as red.
d. Blue has 2 times the power as red.
e. Blue has 4 times the power as red

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

7. A typical x-ray photon used in a dentist's office to produce an x-ray of your teeth has an energy of 10,000 eV. Its wavelength is about

   a. 0.1 nm
   b. 1 nm
   c. 10 nm
   d. 100 nm
   e. 1000 nm

8. A hydrogen atom has quantum states with energies $-13.6\text{eV}/n^2$. Which of the following transitions emits the **shortest** wavelength photon?

   a. n=2 to n=1
   b. n=3 to n=2
   c. n=3 to n=1
   d. n=4 to n=3
   e. all emit the same wavelength photon

9. A particle in a box has quantum states with energies $E=E_o n^2$, with n=1,2,3,4… and E_o=1 eV. Which of these photons could in principle be absorbed?

   a. 1 eV
   b. 2 eV
   c. 4 eV
   d. 5 eV
   e. 6 eV

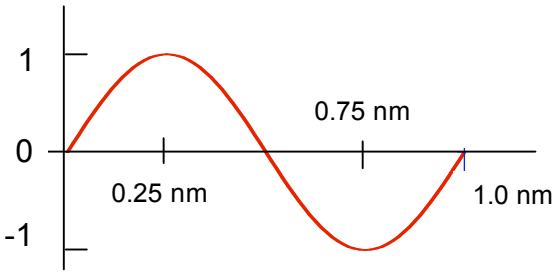
10. The energy levels of a hydrogen atom are given by $E = -13.6/n^2$ eV.
Calculate the wavelength of a photon emitted as a result of the n=4 to n=3 transition.

a. 2700 nm
b. 1875 nm
c. 360 nm
d. 820 nm
e. 650 nm

11. An electron is confined to a box of length L. It is in an excited state. The momentum of the particle is uncertain because

a. the particle is not in the quantum ground state.
b. the concept of momentum is not well-defined.
c. the particle is moving in two different directions.
d. the particle has an electrostatic charge.
e. the particle could quantum-mechanically tunnel out of the box.

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.



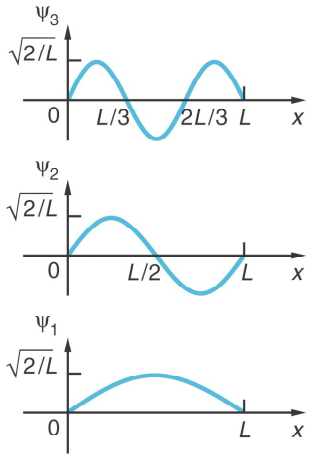
a. P(0.25 nm)=P(0.75 nm)
b. P(0.25 nm)<P(0.75 nm)
c. P(0.25 nm)>P(0.75 nm)
d. the probabilities are uncertain
e. need to know mass of particle

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

a. between all nucleons
b. between protons only
c. between neutrons only
d. between a proton and a neutron only
e. between protons and electrons only

14. Below are three wavefunctions for a particle in a box. Which has the highest energy?

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



15. ^{8}C is an extremely unstable isotope of carbon. It has 6 protons and 2 neutrons in its nucleus. It decays by emitting a positron (anti-particle of electron). After the decay, it becomes

a. ^{7}C
b. ^{9}C
c. ^{8}B
d. ^{8}N
e. ^{7}B

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

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

17. Excited ^{234}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}U
b. ^{232}Pa
c. ^{230}Th
d. ^{230}Ra
e. ^{234}Th

U is the element with 92 electrons
Pa is the element with 91 electrons
Th is the element with 90 electrons
Ra is the element with 88 electrons

18. A particular radioactive nucleus has 60 neutrons and 50 protons in the nucleus. The particle it emits when it decays is likely to be

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

19. The Pauli exclusion principle says that
    a. no two particles are exactly identical
    b. fermions are excluded from the quantum ground state
    c. electrons are fermions
    d. no two fermions can be in the same quantum state
    e. all bosons have spin

20. In a hypothetical nuclear fission event, the original nucleus (binding energy 6 MeV/ nucleon) has 250 nucleons, and splits into two nuclei, each with 125 nucleons (binding energy 6.2 MeV/nucleon). The TOTAL energy released in the fission of ONE nucleus is
    a. 50 MeV
    b. 25 MeV
    c. 0.5 MeV
    d. 620 MeV
    e. 0.2 MeV

21. An energy band in a solid is
    a. A band connecting atoms in the crystal
    b. A region of high energy concentration in the crystal
    c. An energy range densely packed with quantum states
    d. A band of low-energy atoms in a crystal.
    e. A single quantum state on a group of atoms in the crystal.