PHY 122 practice final exam, May8, 2009

1. The actual final will be closely similar in style, not harder than this practice exam.

2. Important constants of nature like *e*, *m*, *h*, *c*, k_B, N_A, *u*, will NOT be given in the exam. If you don't know them, then you should bring them on your 3 sheets.

3. Unimportant constants, like the mass of the neutral H atom to 7 significant figures, will be given on the exam if needed. If uncertain what constants are important or unimportant, you have plenty of room on your three pages to avoid risk.

4. PLEASE check back on Blackboard and/or course web page to find your room assignment.

5. The official course blog has 7 new categories for questions; one section each for (a) problems 1-5 (b) problems 6-10, (c) problems 11-13 (relativity) (d) problems 14-18, (e) problems 19-22, (f) problems 23-26, and (g) problems 27-30. Please target your blog questions appropriately and we will try to provide helpful responses.

6. Management is unwilling or else unable to answer all questions about the nature of the exam, how to study, what to study, and what will count how much. We may read such questions and might respond if the issue is truly unclear and important, but we feel that we have already answered them adequately.

7. This practice exam has not been proofread as rigorously as we had hoped to do. If errors are discovered, we will post corrections on the relevant blog pages.

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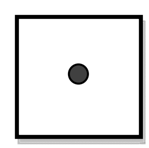
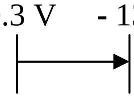
1. In the square shown (15 *cm* on a side) the two lower corners are occupied by α particles and the two upper corners are empty. The magnitude of the electric field at the center of the square is



A. 3.62×10^{-7} *N/C*
B. 4.91×10^{-12} *N/C*
C. 5.13×10^{9} *N/C*
D. 1.92×10^{-9} *N/C*
E. 2.53×10^{-2} *N/C*

10.3 V - 13.5 V



2. An electron travels from the left to the right potential shown. The change in potential energy of the electron is

A. $5.12 \times 10^{-19} J$
B. $-5.12 \times 10^{-19} J$
C. $3.81 \times 10^{-18} J$
D. $7.62 \times 10^{-19} J$
E. $-2.06 \times 10^{-19} J$

3. In the circuit shown the current through the 2V battery is

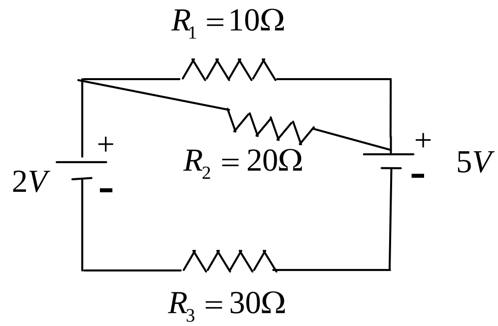
A. 0.050 A

B. 0.12.A

C. 0.115 A

D. 0.082 A

E. 1.08 A



4. The velocity of the proton which travels undeflected through the crossed electric and magnetic fields as shown is

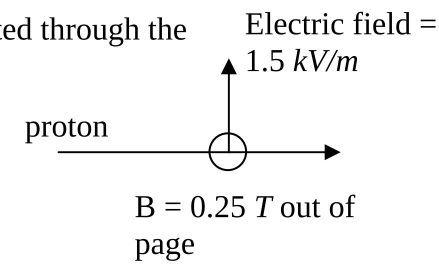
A. 2104 m/s

B. 278 m/s

C. $1.87 \times 10^{-4} m/s$

D. $1.87 \times 10^{4} m/s$

E. 6000 m/s



5. In your lab you insert a bar magnet with the north pole on the right end of the bar into a coil as shown. The current in the coil.

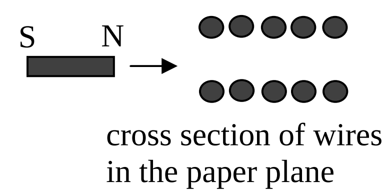
A. is maximal after the bar has come to rest.

B. enters the paperplane at the bottom during insertion.

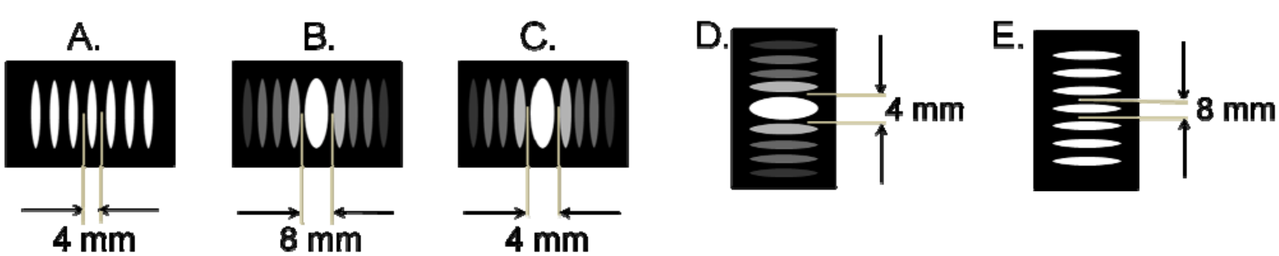
C. exits the paper plane at the bottom during insertion.

D. does not depend on the speed of insertion.

E. does not change its direction when the bar is extracted from the coil.



6. In one of your labs, light from a laser shone on a hair, making a pattern on a wall. If the hair is oriented vertically, the laser has a wavelength of 650 nm, the hair has a diameter of 130 μm, and the wall is 80 cm from the hair, which of these looks the most like the pattern you observe?



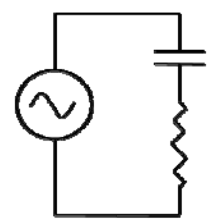
7. A coil of wire with 500 turns in a circle of 3 cm radius is in the horizontal plane. A magnetic field of 0.035 Tesla is oriented vertically (perpendicular to the plane of the loop). The mad scientist who operates the magnet reduces its field to zero and then increases it to 0.035 Tesla pointing in the opposite direction, in a total time of 5 seconds. What is the induced voltage produced in the coil during this time?

A. 0.02 Volt
B. 0.04 Volt
C. 0.01 Volt
D. 0.20 Volt
E. 0.10 Volt

8. A capacitor is charged to 100 volts, and then connected to a resistor of 2×10^5 Ohm. One second later, the capacitor voltage is 1 volt. Which of these answers is closest to the value of the capacitor?

A. 5×10^{-8} Farad
B. 5×10^{-6} Farad
C. 1.2×10^{-5} Farad
D. 1.1×10^{-6} Farad
E. 2.3×10^{-5} Farad

9. If I double the frequency that is driving the series RC circuit shown, the impedance will:



A. Double
B. Increase, but by a factor less than two
C. Decrease, but be more than half the original value
D. Halve
E. Decrease to less than half the original value

10. Light with a wavelength of 550 nm in vacuum enters a piece of glass, where the index of refraction is 1.33. Which of the following statements is correct?

A. The frequency in glass is 7.25×10^{14} Hz
B. The frequency in glass is 1.83×10^{-15} Hz
C. The frequency in glass is 4.10×10^{14} Hz
D. The wavelength in glass is 731 nm
E. The wavelength in glass is 414 nm

11. A measuring stick flies past you at a speed v = 2.5 x 10^8 m/s. With a high speed camera and electronic circuitry, you are able to measure that a time interval Δt = 1.00 x 10^{-9} s elapses between arrival of successive distance markings on the stick. From this you observe that the spacing between marks on the stick is 0.25 m. What is the separation measured in the rest frame of the stick?

a. 0.10 m
b. 0.14 m
c. 0.25 m
d. 0.45 m
e. 0.61 m

12. A particle's kinetic energy is measured to be 8.00 x 10^{-9} J and its velocity is measured to be 2.9 x 10^8 m/s. What is its rest mass?

a. 5.8 x 10^{-27} kg
b. 8.9 x 10^{-27} kg
c. 3.1 x 10^{-26} kg
d. 8.9 x 10^{-26} kg
e. 3.5 x 10^{-25} kg

13. You are on a spacecraft going away from earth at a speed of 8.1 x 10^7 m/s, and broadcasting messages using a frequency of f_0 = 88 kHz. You should tell your friends at home to tune their receivers to

a. 67 kHz
b. 85 kHz
c. 91 kHz
d. 102 kHz
e. 116 kHz

14. Monochromatic X-rays of wavelength λ = 1.21 x 10^{-10} m emerge from a crystal with their direction deflected through an angle of 34^o. From this you deduce that

a. The crystal has an index of refraction greater than 1.79
b. The atoms of the crystal repel X-rays.
c. The atoms of the crystal lie in planes whose separation is 2.07 x 10^{-10} m.
d. The atoms of the crystal lie in planes whose separation is 2.16 x 10^{-10} m.
e. The atoms of the crystal lie in planes whose separation is 4.14 x 10^{-10} m.

15. Gold metal (atomic mass 197) has mass density 19.3 g/cm^3. If the atoms are packed tightly and modeled as little cubes, what is the edge length of the cube?

a. 0.119 nm
b. 0.26 nm
c. 0.55 nm
d. 1.19 nm
e. 2.6 nm

16. Alpha particles (mass 4.00 u) emerge from a nuclear decay with speed 5.2 x 10^5 m/s. A narrow beam is selected which then travels to a region of constant magnetic field (B = 0.040 T) perpendicular to the beam velocity. The alphas then have curved orbits, with radius of curvature
a. 0.067 m
b. 0.135 m
c. 0.27 m
d. 0.54 m
e. 1.08 m

17. The half life of $^{28}_{13}$Al is 2.24 minutes. The activity of the sample at t=0 is 48,000 s^{-1}. How long must you wait until the activity is 10^{-3} s^{-1}?
a. 24 min
b. 39 min
c. 57 min
d. 105 min
e. 310 min

18. An alpha particle is shot at a target. It comes momentarily to rest close to a nucleus of $^{208}_{82}$Pb, and then returns along the same path. Its kinetic energy is measured to be 4.2 MeV. How close did it get to the center of the nucleus?
a. 1.4 x 10^{-14} m
b. 2.8 x 10^{-14} m
c. 5.6 x 10^{-14} m
d. 7.1 x 10^{-14} m
e. 1.4 x 10^{-13} m

19. An electromagnetic standing wave is formed in the lowest normal mode (E-field zero at the end points) of a one-dimensional cavity of length 10 μm. What is the corresponding photon energy?
a. 0.06 eV
b. 0.12 eV
c. 0.24 eV
d. 1.2 eV
e. 6.1 eV

20. You have a black-body source, a diffraction grating with spacing d = 5.0μm, and an infrared camera. Your camera records the pattern of black-body light after it has passed through the diffraction grating at "normal incidence" (perpendicular to the grating.) The peak intensity of the first-order diffraction is at angle θ = 23^o. What is the temperature of the black body?
a. 0^{o}C
b. 27^{o}C
c. 107^{o}C
d. 810^{o}C
e. 1210^{o}C

21. Bohr's theory explains
a. the size of the hydrogen atom.
b. light absorption probability of the hydrogen atom.
c. chemistry of hydrogen.
d. mass of hydrogen.
e. all of the above.

22. The Kα X-rays emitted by a certain element have wavelength 2.97 x 10^{-11} m. The element is probably
a. $_{57}$La
b. $_{60}$Nd
c. $_{62}$Sm
d. $_{65}$Tb
e. $_{70}$Yb

23. An electron is confined in one dimension in a hard-walled box (infinitely deep potential well. It is in the third quantum state with quantum number n=3. The energy of this state is 6.6 eV (above the bottom of the well which is zero energy.) What is the length L of the well where it is confined?
a. 5.4 x 10^{-10} m
b. 7.2 x 10^{-10} m
c. 7.6 x 10^{-10} m
d. 1.1 x 10^{-9} m
e. 2.2 x 10^{-9} m

24. Very careful measurements reveal that the alpha particles that emerge from a certain nuclear α-decay have a range of energies ±0.25 eV. What does this tell us about the α-decay?
a. There must be a corresponding uncertainty in the energy levels of the original nucleus.
b. The half life of the original nucleus must have been only a few fs.
c. The quantum description of α-decay will not obey energy conservation.
d. Both a and b.
e. All 3 of a, b, and c.

25. The highest energy occupied orbitals of the Ru atom have principal quantum numbers (n, l) = (5,0) and (4,2). There are 8 such "outer" electrons. How many electrons all together does Ru have?
a. 34
b. 38
c. 44
d. 50
e. 58

26. The following statements might not all be true:
I. A particle in free space can be described by a wave function with a spread of momenta.
II. The uncertainty principle says that a particle in free space either has completely uncertain position or else it has a wave function that contains a spread of momenta.
III. Diffraction of the quantum wave function means that the corresponding particle does not hit the detector at a single place, but hits simultaneously at all of the diffraction maxima.
IV. If the particle hitting a detector has a well-defined position, that proves that it was a particle and could not had the wave experience of going through multiple slits simultaneously.
a. I and II are true; III and IV are false.
b. I and II are false; III and IV are true.
c. I and III are true; II and IV are false.
d. I and III are false; II and IV are true.
e. All four are false.

27. Bothe's experiment that lead to Chadwick's discovery of the neutron was to bombard $^{9}_{4}Be$ with α-particles; the result was emission of neutrons. Forget about the neutrons for now. There is a minimum kinetic energy of the α necessary for it to get to the edge of the $^{9}_{4}Be$ nucleus. How big is this energy?
a. 2.7×10^4 eV
b. 1.3×10^5 eV
c. 4.6×10^6 eV
d. 2.9×10^7 eV
e. 1.5×10^8 eV

28. What is the binding energy per nucleon of the $^{9}_{4}Be$ nucleus? Some data you may need are the masses of neutral $^{9}_{4}Be$ (9.012182 u), neutral H (1.007825 u), the neutron (1.008665 u), the proton (1.007226 u) and the electron (0.000549 u)
a. 6.46 MeV
b. 6.83 MeV
c. 7.01 MeV
d. 7.33 MeV
e. 7.60 MeV

29. What is the maximum kinetic energy available to the electron emitted in the β-decay of $^{14}_{6}C$? Some data: mass of neutral $^{14}_{6}C$ = 14.003242 u, mass of neutral $^{14}_{7}N$ = 14.003074 u, mass of electron = 0.000549 u.
a. 107 keV
b. 156 keV
c. 233 keV
d. 402 keV
e. 630 keV

30. One of the fission reactions occurring in the sun is ${}^{3}_{2}\text{He} + {}^{3}_{2}\text{He} \rightarrow {}^{4}_{2}\text{He} + \text{p} + \text{p}$. How much energy is released (this energy goes to kinetic energy of the products, especially the two protons. Be careful about electron masses). Data: M(${}^{3}_{2}\text{He}$) = 3.016029 u, M(${}^{4}_{2}\text{He}$) = 4.002603 u, M(charged proton) = 1.007226 u, M(neutral H) = 1.007825 u, M(electron) = 0.000549 u.

a. 11.33 MeV
b. 11.84 MeV
c. 12.35 MeV
d. 12.86 MeV
e. 13.37 MeV