Physics 112
Final Exam
May 22, 2001

Name _____

SS# _____

e = 1.60 × 10^{-19} C

mass of proton = 1.7 × 10^{-27} kg

G = 6.7 × 10^{-11} N m^2/kg^2

k = 9 × 10^{9} N m^2/C^2

c = 3 × 10^{8} m/s

h = 4.14 × 10^{-15} eV-s

$$\mu_0 = 4\pi \times 10^{-7} \frac{N}{A^2}$$

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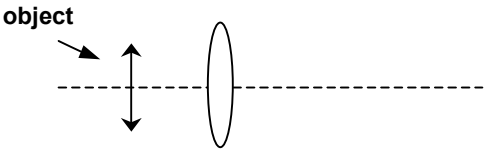
Put ALL of your answers on the Answer Sheet
#1-14 are NO PARTIAL CREDIT; 4 points each. Some have the extra credit option. If you want one of them graded out of 4.5 points (–1 [minus one] for wrong answer!!!) mark the indicated box on the Answer Sheet with an "X."

#8-#15 points as shown Show ALL answers on the Answer Sheet. NO ANSWERS WRITTEN ON QUESTION SHEET WILL BE CONSIDERED!

TOTAL: 100 points.

1. Which statement concerning electromagnetic waves is ***false***?
   A. Electromagnetic waves can travel through a vacuum, i.e. "empty space."
   B. Electromagnetic waves can transfer energy to charged particles by making them oscillate.
   C. Electromagnetic waves can be produced by oscillating electric charges.
   D. Electromagnetic waves always travel with velocity *"c"* no matter what material they are traveling through.
   E. Short-wavelength electromagnetic wave photons have more energy than long-wavelength photons.
   F. X-rays have shorter distance between peaks in their electric field pattern than do infrared waves.
   G. E-M waves consist of mutually perpendicular electric and magnetic fields that oscillate perpendicular to the direction of propagation.
   H. If you view an oncoming e-m wave through a polarizing filter, the electric field would seem to oscillate up and down along just one axis (e.g., pointing toward positive x, then negative x, etc.)

2. A lens forms an image of an object; the object is 6 cm from the lens. (The object is a double-sided arrow, as shown.) Light rays from the ***top*** of the object converge at a point 12 cm from the lens, on the side of the lens opposite the object. Then light rays from the ***bottom*** of the object:



   A. will converge at the same point as those from the top of the object.
   B. will converge at a point *less* than 12 cm from the lens.
   C. will converge at a point *more* than 12 cm from the lens.
   D. will converge at a *different* point than those from the top, but one that is also 12 cm from the lens.
   E. will converge at the focal point.
   F. will not converge anywhere on the side opposite the object.

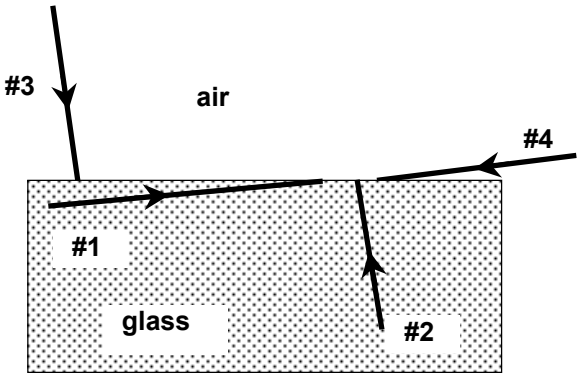
3. A gamma ray photon strikes a hydrogen atom. Which of the following might happen? (Note: In hydrogen, $E_1 = -13.6$ eV; $E_6 = -0.38$ eV; $E_\infty = 0$ eV)
   A. The electron will be raised from the ground state to the fifth "excited" state, i.e. to $n = 6$.
   B. The electron will be raised from the ground state to an excited state with n larger than 6, but will still be bound in the atom.
   C. The electron in the atom will drop down to the ground state.
   D. The electron will be removed from the atom.
   E. The electron will completely disappear and be converted into electromagnetic energy.

4. A rigid loop of wire is connected to a bulb, and rotated (by turning it with a crank) in a constant uniform magnetic field. The loop is rotated at a constant rate, and the bulb is lighted. Suppose a bulb with ***smaller resistance*** is substituted for the bulb already in place, but the *rate* at which the loop is rotated ***does not change***. Then for the ***new*** bulb, compared to the original bulb: [Choose the ***two*** correct answers]
   A. more current will flow through the bulb
   B. less current will flow through the bulb
   C. the same amount of current will flow through the bulb
   D. not enough information to determine whether current will change
   E. it will be harder to turn the loop (more work required each second)
   F. it will be easier to turn the loop (less work required each second)
   G. it will be neither easier nor harder to turn the loop (same work required each second)

5. When a 4-Ω resistor and an 8-Ω resistor are connected in series to a battery, 2 A of current flows out of that battery. If those ***same*** resistors are connected in parallel to that ***same*** battery, how much current will flow ***in*** to that battery?
   A. 2 A
   B. 4 A
   C. 6 A
   D. 8 A
   E. 9 A
   F. 12 A
   G. 24 A
   H. 64 A

6. The current flowing in the 6-Ω resistor is 4 A. The potential difference between points A and B is:
   A. 0.75 V
   B. 0.8 V
   C. 1.25 V
   D. 12 V
   E. 20 V
   F. 24 V

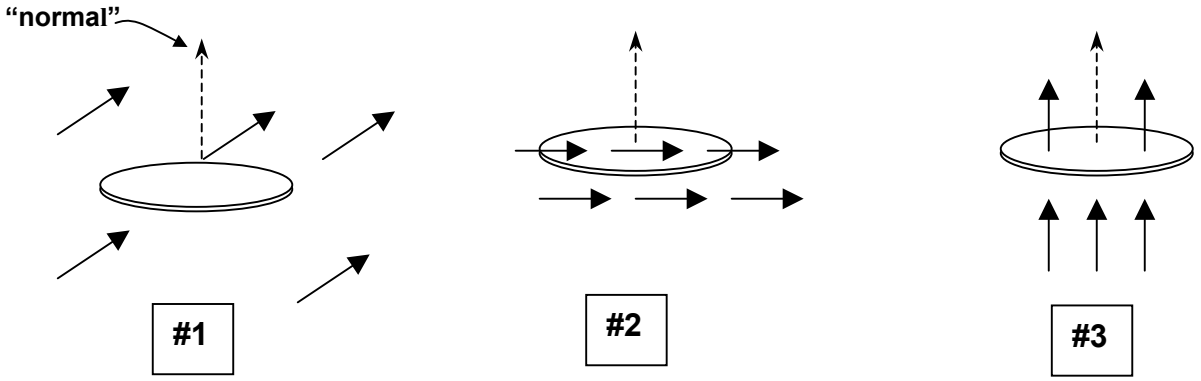
7. The diagram shows a chunk of glass (n = 1.50) surrounded by air. Which of the four light rays will be totally internally reflected?
   A. #1 only
   B. #2 only
   C. #3 only
   D. #4 only
   E. #1 and #2
   F. #3 and #4
   G. #1 and #4
   H. #2 and #3
   I. #1 and #3
   J. #2 and #4
   K. all four of them
   L. none of them



8. An electromagnetic wave travels a distance equal to 25λ in 0.004 s. What is the period of this wave?

   A. 1.6×10^{-4} s
   B. 1.6×10^{-5} s
   C. 1.6×10^{-6} s
   D. 6.25×10^{3} s
   E. 6.25×10^{4} s
   F. 6.25×10^{5} s
   G. 4.8×10^{4} s
   H. 4.8×10^{5} s
   I. 4.8×10^{6} s

9. A loop of wire is placed in a magnetic field, and a galvanometer [current detector] is connected to the loop. Which type of field will result in the greatest deflection of the galvanometer needle? *In the three diagrams below, the dashed arrow represents the normal to the plane of the loop, and the solid arrows represent the magnetic field.*



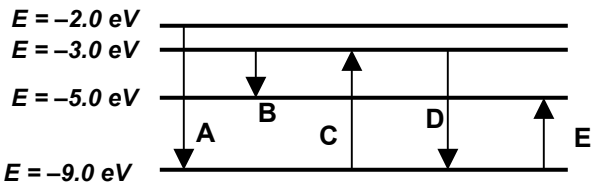
   A. Orientation #1, with initial B = 2 T and increasing at 5 T/s.
   B. Orientation #1, with initial B = 20 T and increasing at 4 T/s
   C. Orientation #1, with initial B = 2 T and decreasing at 6 T/s
   D. Orientation #2, with initial B = 2 T and increasing at 5 T/s.
   E. Orientation #2, with initial B = 20 T and increasing at 4 T/s
   F. Orientation #2, with initial B = 2 T and decreasing at 6 T/s
   G. Orientation #3, with initial B = 2 T and increasing at 5 T/s.
   H. Orientation #3, with initial B = 20 T and increasing at 4 T/s
   I. Orientation #3, with initial B = 2 T and decreasing at 6 T/s

10. A blue light and a red light are switched on at exactly the same moment on a distant planet. Assuming that both travel entirely through empty space (vacuum) on their way to earth, which light will be seen first on earth:

   A. The red light will be seen first on earth.
   B. The blue light will be seen first on earth.
   C. Both lights will be seen at exactly the same moment on earth.
   D. The answer will depend on the distance between the planet and the earth.

11. What does arrow B represent?

A. emission of a photon of radio waves
B. absorption of a photon of radio waves
C. emission of a photon of visible light
D. absorption of a photon of visible light
E. emission of a photon of gamma rays
F. absorption of a photon of gamma rays



12. Suppose a 2-ohm and a 6-ohm resistor are connected in series to a battery, and $\Delta V_{2\Omega} = 4$ volts. If the same two resistors are connected to the ***same*** battery in a parallel circuit, what would be the magnitude of $I_{2\Omega}$?

A. 1 A
B. 2 A
C. 3 A
D. 4 A
E. 6 A
F. 8 A
G. 12 A

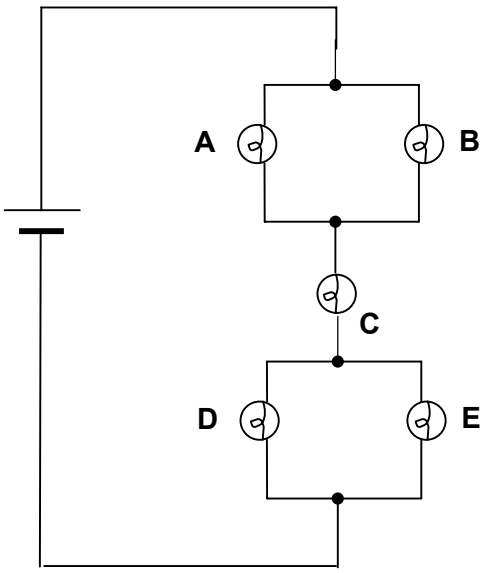
13. Wire "A" is parallel to the y axis, at x = –3 m; it carries a current of 4 A flowing toward positive y. Wire "B" is parallel to the y axis, at x = +3 m. Initially, the current in wire "B" is zero and the ***net*** magnetic field at the origin is *M*. What will the net magnetic field at the origin become if a 16 A current begins to flow in wire "B" ***toward negative y?***

A. 0
B. *M*/4
C. *M*/2
D. *M*
E. 2*M*
F. 3*M*
G. 4*M*
H. 5*M*

14. If you use a convex lens to focus an image of the sun into a sharp point on a leaf, the leaf may begin to burn. (The sun may be considered an infinitely distant point source.) When that happens, the distance between the lens and the leaf is:

A. much less than the focal length of the lens
B. equal to the focal length of the lens
C. much more than the focal length of the lens
D. not related to the focal length of the lens.

15. The circles in this diagram represent ***identical*** light bulbs.



A) *[4 points]* Rank the bulbs A, B, C, D and E in order of brightness.

B) [*2 points]* Explain your reasoning.

16. The electric potential all along the line x = 0 (i.e., the y axis) is 3 V, the potential all along the line x = 1 m is 4 V, along x = 3 m is 5 V, along x = 6 m is 6 V, and along x = 12 m is 7 V.

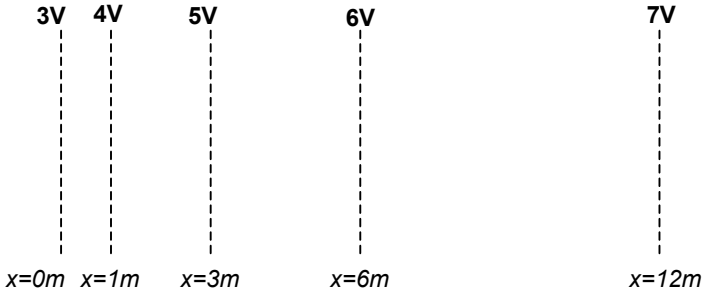
The following 4 particles have ***equal mass*** and ***equal magnitude charge***. They all start from rest at the point indicated.

#1: A positive charge placed at x = 3 m.

#2: A positive charge placed at x = 6 m.

#3: A negative charge placed at x = 3 m.

#4: A negative charge placed at x = 6 m.



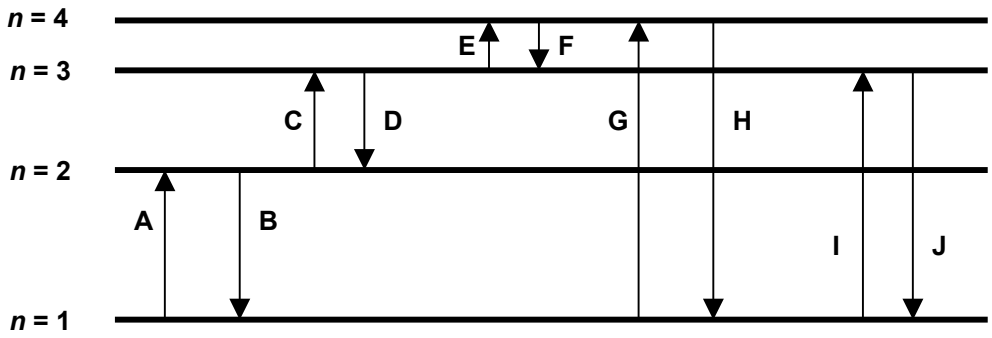
(A) *[3 points]* Which has the ***highest speed after traveling for 3 m?***

(B) *[2 points]* Which has the ***lowest speed after traveling for 3 m?***

17. *[6 points]* A ***two-gram*** sample of freshly cut tree bark produces 32 "clicks" per second in a Geiger counter, each click corresponding to one nucleus decaying. Assuming that all clicks come from ^{14}C nuclei [half life = 5730 years] decaying away, state [in A, B, and C] how many clicks per second would be expected from the following samples of ancient tree bark found frozen in ice:
    A) A two-gram sample one year old.
    B) A two-gram sample 11,500 years old.
    C) A one-gram sample 17,200 years old.
    D) What is the minimum probable age of a ***4-gram*** sample that produced no clicks in one second?

18. *[5 points]* In the energy level diagram shown on the answer sheet, the energy ***difference*** between the $n = 2$ level and the $n = 3$ level (ΔE_{23}) corresponds to the energy of a photon of blue light. On the diagram, draw and label the following (there *might* be more than one possible choice for each one):
    A) *[3 points]* a transition corresponding to the emission of infrared light
    B) *[2 points]* a transition that could correspond to the absorption of ultraviolet light

19. *[5 points]* The set of spectral lines on the answer sheet is observed when viewing a glowing gas in a discharge tube (such as used in class). These are all bright, colored lines. The energy-level diagram of the gas is shown below. Under (or on) each line on the answer sheet, write the letter of the corresponding transition.



Note*: Larger spacing between lines indicates larger energy differences. In some cases spacing has been exaggerated for clarity.*

20. *[5 points]* A conducting loop sits in a 4 T magnetic field. A clock is started (at which time it reads "0 seconds"), and at the same moment the magnetic field starts increasing at a steady rate.

When the magnetic field magnitude reaches 10 T, the clock reads "6 seconds." Then the magnetic field is held constant at 10 T. At "8 seconds," the magnetic field starts increasing again at a steady rate until it reaches 14 T, at which time the clock reads "10 seconds."

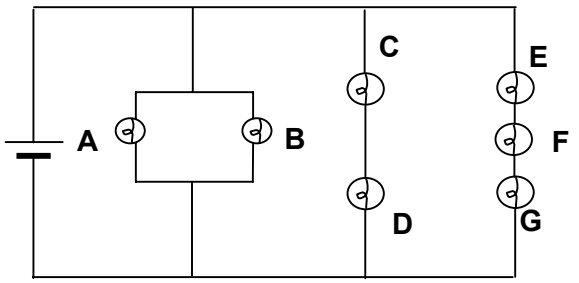
You are measuring the current in the loop while all this happens. You make three measurements: (1) when the clock reads "5 seconds"; (2) when the clock reads "7 seconds"; (3) when the clock reads "9 seconds." One of the current measurements is shown below. Fill in the other two. (If there is no direction, write "none.")

Current at 5 seconds = *12 A*, direction = *clockwise*

A. i) Current at 7 seconds = ? ii) direction = ?

B. i) Current at 9 seconds = ? ii) direction = ?

21. The circles in this diagram represent ***identical*** light bulbs.



A) *[4 points]* Rank the bulbs A, B, C, D, E, F and G in order of brightness.

B) *[2 points]* Explain your reasoning.

22. *[6 points]* A 3 microcoulomb charge is fixed at the origin. The electric potential infinitely far away from this charge is zero volts. A 4 microcoulomb charge is released from rest at a point 1 m from the origin. Draw ***four*** bar graphs, one each corresponding to the situation when the charge is 1 m, 2 m, 3 m, and an infinite distance from the origin. Each bar graph should have three bars, one corresponding to the total energy (TE), one to the kinetic energy (KE), and one to the electric potential energy (PE) of the 4 microcoulomb charge. ***Label the energy axis with appropriate numbers (more than one number!)*** :

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Name: _____

1. _____ ***Grade out of 4.5? Mark "X" here:*** _____

2. _____ ***Grade out of 4.5? Mark "X" here:*** _____

3. _____ ***Grade out of 4.5? Mark "X" here:*** _____

4. _____ ; _____

5. _____ ***Grade out of 4.5? Mark "X" here:*** _____

6. _____ ***Grade out of 4.5? Mark "X" here:*** _____

7. _____ ***Grade out of 4.5? Mark "X" here:*** _____

8. _____ ***Grade out of 4.5? Mark "X" here:*** _____

9. _____ ***Grade out of 4.5? Mark "X" here:*** _____

10. _____ ***Grade out of 4.5? Mark "X" here:*** _____

11. _____ ***Grade out of 4.5? Mark "X" here:*** _____

12. _____ ***Grade out of 4.5? Mark "X" here:*** _____

13. _____ ***Grade out of 4.5? Mark "X" here:*** _____

14. _____ ***Grade out of 4.5? Mark "X" here:*** _____

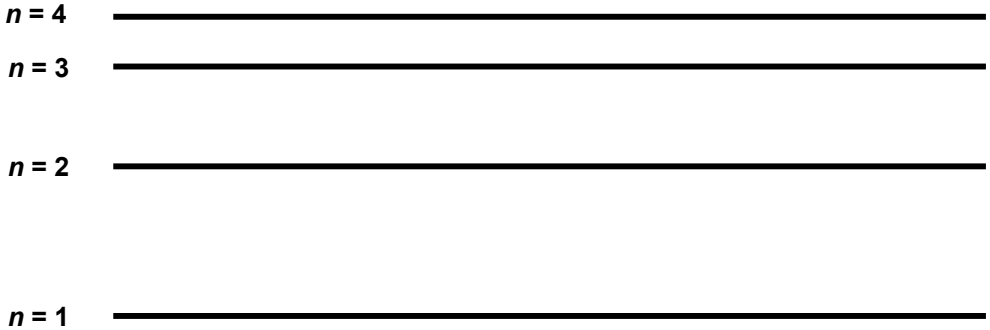
15. (A) Ranking: (brightest) _____(dimmest)

(C) Explanation:

16. (A): _____ (B): _____

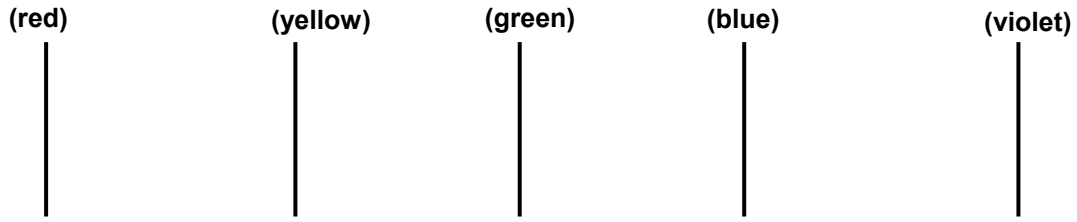
17. (A): _____ (B):_____ C): _____ (D):_____

18.



Note: spacing between lines is proportional to energy differences

19.



20. A. i) _____ ii) _____

B. i) _____ ii) _____

21. (A) Ranking: (brightest) _____(dimmest)

(B) Explanation:

22.