

Physics 204 Final Exam  
May 13, 2008  
George Horton

Name: \_\_\_\_\_  
I have read the instructions below.

Your name sticker  
with exam code

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If this were a real exam, your name sticker would be here.
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1. The exam will last from 4:00 to 7:00 P.M. Use a #2 pencil to make entries on the answer sheet. Enter the following id information now, before the exam starts.
2. In the section labelled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit Rutgers ID number.
4. Enter 204 under COURSE, and your section number under SEC. If you don't know your section, leave it blank.
5. **Important:** Under CODE enter the exam code given above.
6. During the exam, you may use a calculator and are allowed one  $8\frac{1}{2} \times 11$  inch sheet of paper with whatever you want *hand-written* on it. Xeroxed or printed sheets are **not permitted** and will be confiscated.
7. The exam consists of 34 multiple choice questions. For each multiple choice question mark only one answer on the answer sheet. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess.
8. Turn off any cell phone or other communication device, and pack it away in a place clearly inaccessible. You may not use your cell-phone as a clock or in any other way during the exam.
9. Before starting the exam, make sure that your copy contains all 34 questions. Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
10. A proctor will check your name sticker and possibly your student ID when you turn in the exam. Please have them ready.
11. You are not allowed to give help to any other student, ask for help from anyone but a proctor, or change your seat without permission from a proctor. Doing so will result in a zero score for the exam.
12. Please hand in the cover sheet and the answer sheet. You may take the rest of the exam with you when you leave.
13. Please sign in at the top to indicate that you have read and understood these instructions.
14. Some constants are given on the last page.

1. A proton is moving parallel to the page and toward its left edge when it enters a magnetic field. Because of this magnetic field the proton starts curving downward toward the bottom of the page. What is the direction of this magnetic field?

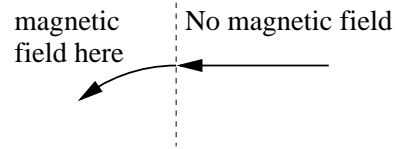
a. In the plane of the paper toward the bottom of the page.

b. In the plane of the paper toward the top of the page.

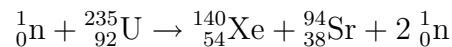
c. In the plane of the paper and toward its right side.

d. Perpendicular to and out of the paper.

e. Perpendicular to and into the paper.



2. When a slow neutron collides with a uranium-235 nucleus, it causes the following fission reaction.



The masses of these particles and the neutral atoms are:  ${}^1_0\text{n}$  has mass 1.008665 u,  ${}^{235}_{92}\text{U}$  has mass 235.043924 u,  ${}^{140}_{54}\text{Xe}$  has mass 139.921620 u, and  ${}^{94}_{38}\text{Sr}$  has mass 93.915367 u. What answer below is closest to the energy released in the reaction?

[Note: 1 u = 931.494 MeV/c<sup>2</sup>.]

a) 185 MeV

b) 202 MeV

c) 32.6 MeV

d) 65.7 MeV

e) 156 MeV

3. John's face is 20 cm in front of a concave shaving mirror. If he observes an upright virtual image that is twice as big as his face, what is the focal length of the mirror?

a) +10 cm

b) +20 cm

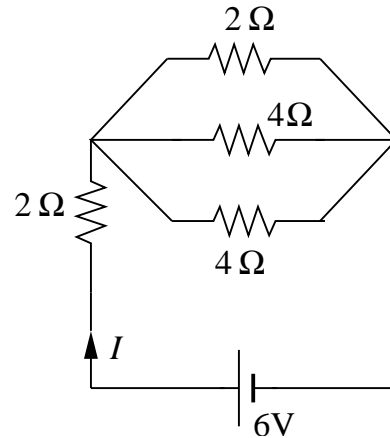
c) +30 cm

d) +40 cm

e) +60 cm

4. Light with a frequency of  $9.50 \times 10^{14}$  Hz is incident on a metal that has a work function of 3.1 eV. Which answer below is closest to the maximum kinetic energy of the electrons ejected in this process?
- $8.7 \times 10^{-19}$  J
  - $3.1 \times 10^{-19}$  J
  - $2.4 \times 10^{-19}$  J
  - $1.3 \times 10^{-19}$  J
  - $6.4 \times 10^{-19}$  J

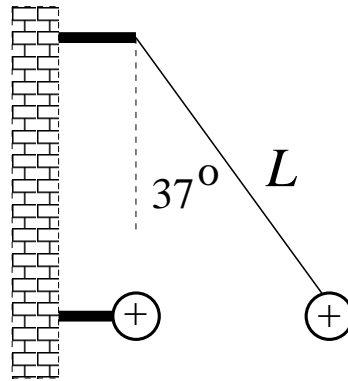
5. Four resistors of values  $2 \Omega$ ,  $2 \Omega$ ,  $4 \Omega$  and  $4 \Omega$  are connected across a 6.0-V battery, as shown. Which answer below is closest to the current through the battery?



- 2.4 A
  - 1.6 A
  - 0.4 A
  - 3.0 A
  - 2.0 A
6. The surface of a circular wire loop of radius 0.090-m is oriented perpendicular to a uniform 0.35-T magnetic field. The loop is pulled from two sides into a long, thin shape with the two sides next to each other and the area inside now zero. The change of shape occurs in 0.11 s. What answer below is closest to the average induced emf while the loop is being pulled?
- 0.08 V
  - 0.3 V
  - 0.04 V
  - 0.9 V
  - 0.20 V
7. When  ${}^{223}_{87}\text{Fr}$  emits an alpha particle (a helium nucleus  ${}^4_2\text{He}$ ), the resulting daughter nucleus will be which of the following?
- ${}^{219}_{86}\text{Rn}$
  - ${}^{219}_{85}\text{At}$
  - ${}^{211}_{83}\text{Bi}$
  - ${}^{211}_{82}\text{Pb}$
  - ${}^{213}_{82}\text{Pb}$

8. A metal ball with charge  $q_2 = 4.0 \times 10^{-6}$  C hangs at the end of a string. This ball is 0.30 m from the fixed ball attached to the wall and with charge  $q_1 = 9.0 \times 10^{-5}$  C. Which answer below is closest to the tension in the string?

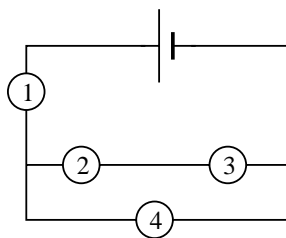
- a) 90 N
- b) 60 N
- c) 40 N
- d) 50 N
- e) 80 N



9. You first shine a 400-nm blue laser, then a 550-nm green laser, and finally a 700-nm red laser on the same double slit. The light from each laser passes through the slits to a screen. In which case is the distance on the screen of the first bright band to the side of the central maximum the greatest?
- a) When shining the 700-nm red light.
  - b) When shining the 550-nm green light.
  - c) When shining the 400-nm blue light.
  - d) The separation of the bright bands is the same for all of the colors of light.
  - e) The separation increases if you use more intense light.
10. A mallet found at an archeological excavation site has  $1/8$  the normal carbon-14 concentration compared to that in a fresh bone. The half-life of carbon-14 is about 6000 years. What answer below is closest to the mallet's age?
- a) 18,000 years
  - b) 48,000 years
  - c) 750 years
  - d) 2000 years
  - e) 48,000 years

11. Rate the four identical light bulbs in order of brightness, the brightest bulb being listed first.

- a)  $1 > 4 > 2 > 3$
- b)  $1 > 2 = 3 = 4$
- c)  $1 = 2 = 3 = 4$
- d)  $1 > 4 > 3 > 2$
- e)  $1 > 4 > 2 = 3$



12. An proton, initially at rest, moves across a region with a potential difference of  $-470$  V. Which answer below is closest to the speed of the proton after crossing this potential difference?

- a)  $1.0 \times 10^5$  m/s
- b)  $1.6 \times 10^5$  m/s
- c)  $2.0 \times 10^5$  m/s
- d)  $3.0 \times 10^5$  m/s
- e)  $4.3 \times 10^5$  m/s

13. A voltage of  $V(t) = (120 \text{ V}) \sin[(302 \text{ rad/s})t]$  is produced by an AC generator. What is the rms voltage and the frequency of the source?

- a) 170 V and 213 Hz
- b) 19 V and 427 Hz
- c) 60 V and 151 Hz
- d) 85 V and 48 Hz
- e) 85 V and 302 Hz

14. Which one of the following sets of quantum numbers is *not* possible?

- |    | $n$ | $\ell$ | $m_\ell$ | $m_s$ |
|----|-----|--------|----------|-------|
| a) | 2   | 3      | -2       | +1/2  |
| b) | 4   | 3      | +2       | +1/2  |
| c) | 3   | 1      | 0        | -1/2  |
| d) | 6   | 2      | -1       | +1/2  |
| e) | 5   | 4      | -4       | -1/2  |

15. Incident X-rays in a Compton scattering experiment have a wavelength of 0.400 nm. Determine the wavelength of the X-rays scattered by an electron through an angle of  $80.0^\circ$ .
- a) 0.041 nm
  - b) 0.398 nm
  - c) 0.399 nm
  - d) 0.402 nm
  - e) 0.403 nm
16. Determine the speed at which the kinetic energy of an electron is equal to twice its rest energy.
- a)  $0.45c$
  - b)  $0.63c$
  - c)  $0.87c$
  - d)  $0.94c$
  - e)  $0.99c$
17. A space ship traveling east flies directly over the head of an inertial observer who is at rest on the earth's surface. The speed  $v$  of the space ship relative to this observer is such that

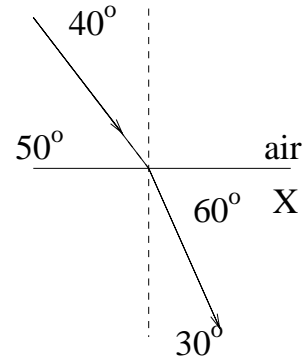
$$\sqrt{1 - \frac{v^2}{c^2}} = \frac{1}{2}.$$

The navigator's on-board instruments indicate that the length of the space ship is 20 m. If the length of the ship is measured by the inertial earth-bound observer, what value will be obtained?

- a) 5 m
- b) 10 m
- c) 20 m
- d) 40 m
- e) 80 m

18. The diagram shows the passage of a ray of light from air into a substance X. The index of refraction of X is:

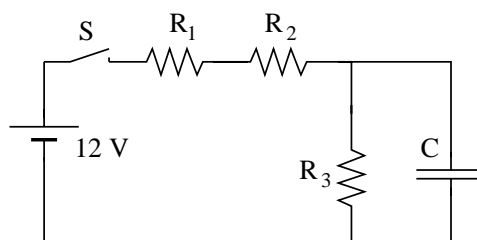
- a) 0.74
- b) 1.15
- c) 1.29
- d) 1.35
- e) 1.47



19. Two long straight wires are parallel and 0.6 m apart. One carries a current of 4 A, and the other carries a current of 12 A, both in the *same* direction. Which statement is true concerning the force between the wires?
- a) The force is repulsive.
  - b) The force is doubled if the spacing of the wires is doubled.
  - c) The force can be made repulsive by reversing the direction of the current in *one* of the wires.
  - d) The force can be made repulsive by reversing the direction of the current in *both* of the wires.
  - e) The force can be quadrupled by increasing the current in the first wire to 8 A.
20. The electron in a hydrogen atom is in the  $n=3$  state. What is (are) possible value(s) for the energy of an emitted photon?
- a) 1.89 eV or 12.09 eV
  - b) 1.89 eV or 13.6 eV
  - c) 0.66 eV or 13.6 eV
  - d) 0.66 eV or 12.09 eV
  - e) 1.51 eV only
21. Suppose the electric field in an electromagnetic wave has a maximum strength of 1470 N/C. What is the maximum strength of the magnetic field of the wave?
- a)  $6.4 \times 10^{-7}$  T
  - b)  $8.8 \times 10^{-7}$  T
  - c)  $1.2 \times 10^{-6}$  T
  - d)  $2.0 \times 10^{-6}$  T
  - e)  $4.9 \times 10^{-6}$  T

22. A parallel-plate capacitor has a plate separation distance of 0.5 cm. A potential difference of 50 V is applied across the plates. The magnitude of the electric field between the plates (not near the edges) is:
- 50 N/C
  - $9.0 \times 10^{13}$  N/C
  - 25 N/C
  - Cannot be determined from the information given.
  - $1.0 \times 10^4$  N/C
23. Which one of the following atomic configurations could be the ground state of some atom?
- $1s^2 2s^1 2p^6$
  - $1s^1 2s^1 2p^1$
  - $1s^1 2s^2 3p^1$
  - $1s^2 2s^2 2p^1$
  - $1s^1 2s^2 2p^1$
24. Gamma rays are:
- low energy, long wavelength electromagnetic radiation.
  - protons.
  - electrons.
  - nuclei of helium atoms.
  - high energy, short wavelength electromagnetic radiation.
25. The circuit shown is assembled from a 12 V battery, three resistors each having the same resistance,  $R_1 = R_2 = R_3 = 2 \Omega$ , an uncharged capacitor with  $C = 6 \mu\text{F}$ , and an open switch S. A moment after the switch is first closed, the current flowing from the battery is

- 3 A
- 2 A
- $2 \times 10^6$  A
- 6 A
- 18 A



26. Which of the following statements is *false*?
- a) The ultraviolet catastrophe (the divergence of blackbody radiation for small  $\lambda$ ) was solved by assuming radiation is quantized.
  - b) The photoelectric effect is evidence for the particle nature of light.
  - c) The momentum and position of a particle cannot be measured with infinite precision at the same time
  - d) The interference pattern created by photons passing through two slits is evidence for the particle nature of light.
  - e) Photons can carry momentum even though their mass is zero.
27. The number of electrons, protons, and neutrons in a strontium-90 ( ${}^{90}_{38}\text{Sr}$ ) atom is:
- a) 38 electrons, 38 protons, 90 neutrons
  - b) 38 electrons, 38 protons, 52 neutrons
  - c) 38 electrons, 52 protons, 52 neutrons
  - d) 90 electrons, 90 protons, 38 neutrons
  - e) 52 electrons, 52 protons, 38 neutrons
28. In the year 2098, an astronaut wears an antique but accurate “quartz” wristwatch on a journey at a speed of  $2.0 \times 10^8$  m/s. According to mission control in Houston, the trip lasts 12 hours. How long was the trip as measured on the watch?
- a) 6.7 hr
  - b) 8.9 hr
  - c) 12.0 hr
  - d) 16.1 hr
  - e) 21.6 hr
29. An object is in front of a thin converging lens, at a distance less than the focal length from the lens. Its image is:
- a) virtual and larger than the object
  - b) real and smaller than the object
  - c) virtual and smaller than the object
  - d) real and larger than the object
  - e) virtual and the same size as the object

30. An electron and a neutron have the same de Broglie wavelength. Which of the following is **true**:
- a) The electron has more kinetic energy and a higher speed.
  - b) The electron has less kinetic energy but a higher speed.
  - c) The electron has less kinetic energy and a lower speed.
  - d) The electron and the neutron have the same kinetic energy but the electron has the higher speed.
  - e) The neutron has more kinetic energy but the two have the same speed.
31. In the notation  ${}^A_ZX_N$  the superscript A represents the:
- a) number of protons in the nucleus.
  - b) number of neutrons in the nucleus.
  - c) atomic number, or unique chemical symbol for the element.
  - d) sum of the number of protons plus the number of neutrons in the nucleus.
  - e) none of these.
32. If an atom had energy levels only at -10 eV, -4 eV, -1 eV, and zero, this atom's electrons could undergo energy changes: attrib204s02f:28 (26,16,43\*,9,6)
- a) only in the amounts of 1 eV, 4 eV and 10 eV.
  - b) only in the amounts of 3 eV, 6 eV and 9 eV.
  - c) only in the amounts of 1 eV, 3 eV, 4 eV, 6 eV, 9 eV and 10 eV.
  - d) These energy levels would not introduce any restriction on electron energy changes.
  - e) None of the other answers.
33. To charge a 1-F parallel plate capacitor with a charge of +2 C and -2 C on the two plates, respectively, requires a potential difference of:
- a) 2 V
  - b) 0.2 V
  - c) 0 V
  - d) 0.5 V
  - e) 4 V

34. A long straight wire is in the plane of a rectangular conducting loop. The straight wire initially carries a constant current  $i$  in the direction shown. While the current  $i$  is being shut off, the current in the rectangle is:

- a) zero
- b) clockwise
- c) counterclockwise
- d) clockwise in the left side and counterclockwise in the right side
- e) counterclockwise in the left side and clockwise in the right side



### Some Constants

electromagnetic permittivity $\epsilon_0$	$8.854 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$
electromagnetic constant $k_e \equiv \frac{1}{4\pi\epsilon_0}$	$8.9875 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$
magnitude of electron charge	$1.602 \times 10^{-19} \text{ C}$
electron mass	$9.11 \times 10^{-31} \text{ kg}$
proton mass	$1.67 \times 10^{-27} \text{ kg}$
magnetic permeability $\mu_0$	$4\pi \times 10^{-7} \text{ T}\cdot\text{m}/\text{A}$
speed of light in vacuum	$2.998 \times 10^8 \text{ m}/\text{s}$
atomic mass unit	$u = 1.6605 \times 10^{-27} \text{ kg} = 931.5 \text{ MeV}/c^2$