

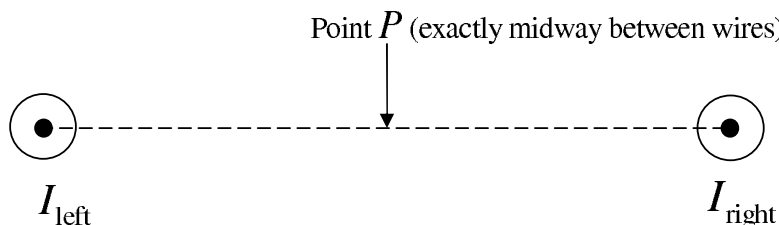
**Physics 262: Physics for Life Sciences II**  
**Third Exam**

- Time allowed: 90 minutes
- Calculators are not permitted.
- Section A contains multiple choice questions. There are 20 questions + 3 more challenging bonus questions, worth 3 points each. Points will not be deducted for incorrect answers in this section, so you should answer all 23 questions, even if they are complete guesses.
- Section B has 2 homework-type problems worth 20 points each. Where appropriate, show how you obtained your answers.
- Solutions will be posted on the course web site after the exam ends.

## SECTION A

1. The north pole of a compass needle points north due to the Earth's magnetic field. If the Earth's magnetic field were due to a giant bar magnet buried inside the Earth, where would this giant magnet's north pole be closest to?
  - (A) The north pole of the Earth.
  - (B) The south pole of the Earth.
  - (C) The international dateline (which goes from the Earth's north to south pole, bisecting the Pacific Ocean).
  - (D) The Greenwich Meridian (which goes from the Earth's north to the south pole, passing through London, England).

The following pertains to questions 2, 3 and 4. Assume that there are two identical long straight current-carrying wires that are perpendicular to this sheet of paper, indicated in the figure below by  $\odot$ 's. The directions of the electric currents in both wires are *out* of the paper, and the magnitudes of the currents of the left and right wires are  $I_{\text{left}}$  and  $I_{\text{right}}$ , respectively. Point  $P$  is *exactly* half way between the two wires.



2. If  $I_{\text{left}} = I_{\text{right}} \neq 0$ , the magnetic field due to the currents points in what direction at  $P$ ?
  - (A) up  $\uparrow$
  - (B) down  $\downarrow$
  - (C) out of paper.
  - (D) the magnetic field is zero.
3. If  $I_{\text{left}} > I_{\text{right}}$ , the magnetic field due to the currents points in what direction at  $P$ ?
  - (A) up  $\uparrow$
  - (B) down  $\downarrow$
  - (C) out of paper.
  - (D) the magnetic field is zero.
4. Assuming that neither  $I_{\text{left}}$  nor  $I_{\text{right}}$  is zero, in what direction are the magnetic forces of one wire on the other?
  - (A) The wires attract one another.
  - (B) The wires repel one another.
  - (C) The forces on both wires are to the left ( $\leftarrow$ ).
  - (D) The forces on both wires are to the right ( $\rightarrow$ ).

5. An argon atom is twice as massive as a neon atom. What is the relation between the root-mean-square (i.e., the square root of the average of the square) of the speeds of the neon atoms ( $v_{\text{rms,Ne}}$ ) and the argon atoms ( $v_{\text{rms,Ar}}$ ) if they are both in an ideal gas state at the same temperature? (Recall that the kinetic energy is  $\frac{1}{2}mv^2$ .)
- (A)  $v_{\text{rms,Ne}} = v_{\text{rms,Ar}}$     (B)  $v_{\text{rms,Ne}} = \sqrt{2}v_{\text{rms,Ar}}$     (C)  $v_{\text{rms,Ne}} = v_{\text{rms,Ar}}/\sqrt{2}$   
 (D)  $v_{\text{rms,Ne}} = v_{\text{rms,Ar}}/2$
6. An ideal gas is kept in a cylinder of fixed volume at an initial temperature of  $27^\circ\text{C}$  and initial pressure of 1 atmosphere. The temperature is changed so that the final pressure of the gas is 2 atmospheres. What is the final temperature?
- (A)  $-123^\circ\text{C}$     (B)  $13.5^\circ\text{C}$     (C)  $54^\circ\text{C}$     (D)  $327^\circ\text{C}$
7. When you boil water in a pot by heating the bottom of the pot on your kitchen stove, which of the following mechanisms is mainly responsible for distributing the heat throughout the water?
- (A) radiation    (B) conduction    (C) convection  
 (D) all three equally
8. The total power radiated (by blackbody radiation) by an object at a temperature of 1200 K is how many times that of the same object at 300 K?
- (A) 4 times    (B) 16 times    (C) 64 times    (D) 256 times
9. If we mix 1 kg of ice at  $0^\circ\text{C}$  with 1 kg of water at  $100^\circ\text{C}$ , what is the final temperature of the water when the mixture comes to thermal equilibrium, assuming no heat escapes? (The specific heat of water is  $4.2\text{ kJ}/(\text{kg}\cdot^\circ\text{C})$  and its latent heat of fusion is  $333\text{ kJ}/\text{kg}$ .)
- (A) less than  $50^\circ\text{C}$     (B)  $50^\circ\text{C}$   
 (C) between  $50^\circ\text{C}$  and  $75^\circ\text{C}$     (D) between  $75^\circ\text{C}$  and  $100^\circ\text{C}$
10. What thickness of wood has the same thermal resistance (or “ $R$ -value”; that is, the same amount of heat loss per unit area for the same temperature difference) as 1.0 m of concrete? (Take the thermal conductivities of wood and concrete are  $k_{\text{concrete}} = 1.3\text{ W}/(\text{m}\cdot^\circ\text{C})$  and  $k_{\text{wood}} = 0.13\text{ W}/(\text{m}\cdot^\circ\text{C})$ , respectively.)
- (A) 0.01 m    (B) 0.1 m    (C) 10 m    (D) 100 m

The following pertains to 11 and 12. A metallic surface of a material with work function  $1.0\text{ eV}$  is illuminated by a beam of monochromatic light wavelength  $\lambda_0$ . The most energetic of these electrons have kinetic energy  $K = 0.5\text{ eV}$ .

11. If the *intensity* of the light beam is increased slightly (everything else kept constant), which of the following would occur?
  - (A) the maximum kinetic energy of the ejected electrons increases, but the rate at which electrons are ejected remains the same.
  - (B) the maximum kinetic energy of the ejected electrons remains the same, but the rate at which electrons are ejected increases.
  - (C) the maximum kinetic energy of the ejected electrons and the rate at which the electrons are ejected both increase.
  - (D) the maximum kinetic energy of the ejected electrons and the rate at which the electrons are ejected both remain the same.
  
12. If the *wavelength* of the laser light is *doubled* to  $2\lambda_0$ , what would the maximum energy of the ejected electrons be?
  - (A)  $2.0\text{ eV}$
  - (B)  $1.0\text{ eV}$ .
  - (C)  $0.25\text{ eV}$
  - (D) No electrons will be ejected from the metal surface.
  
13. Stars emit blackbody radiation. Stars of which of the following colors are the hottest? (The relative sizes of the wavelengths are  $\lambda_{\text{red}} > \lambda_{\text{yellow}} > \lambda_{\text{blue}}$ .)
  - (A) Red
  - (B) Yellow
  - (C) Blue
  - (D) Need information about the mass of the star.
  
14. Three lasers emit monochromatic light, one red, one yellow and one blue, at the same power (*i.e.*, same amount of energy per unit time). Which of these emit the *least* number of photons per unit time?
  - (A) Red
  - (B) Yellow
  - (C) Blue
  - (D) All emit the same number of photons per unit time.
  
15. Which of the following will cause a neutral hydrogen atom to undergo a transition from its ground state ( $n = 1$ ) state to the  $n = 3$  state?
  - (A) Absorption of a  $13.6\text{ eV}$  photon.
  - (B) Absorption of a  $(8/9) \times 13.6\text{ eV} = 12.1\text{ eV}$  photon.
  - (C) Emission of a  $13.6\text{ eV}$  photon.
  - (D) Emission of a  $(8/9) \times 13.6\text{ eV} = 12.1\text{ eV}$  photon.



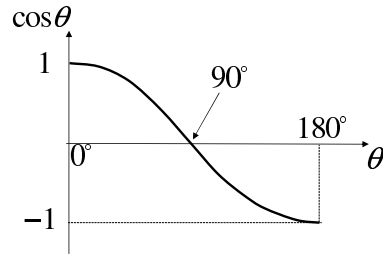
21. **Bonus No. 1:** A block of iron at a temperature of  $0^\circ\text{C}$  has a cavity of volume  $1.0000\text{m}^3$ . When the block is heated to  $100^\circ\text{C}$ , what is the volume of the cavity? The thermal coefficient of linear expansion of iron is  $1.2 \times 10^{-5} \text{C}^\circ^{-1}$ .

(A)  $1.0012\text{m}^3$       (B)  $1.0036\text{m}^3$       (C)  $0.9988\text{m}^3$       (D)  $0.9964\text{m}^3$

22. **Bonus No. 2:** In a mass spectrometer, a velocity selector is used to select charged particles of a certain speed  $v$ . The particles which are then sent into a region of uniform magnetic field of magnitude  $B$  that is perpendicular to the direction of motion of the charge. What is the radius of the circular path taken by the charged particles while they are in the magnetic field, in terms of  $v$ ,  $B$ , and the charge  $q$  and mass  $m$  of the particle? (Recall that the centripetal force for a particle of mass  $m$  moving at a speed  $v$  in a circle of radius  $r$  is  $mv^2/r$ .)

(A)  $\frac{mv}{qB}$       (B)  $\frac{mv^2}{qB}$       (C)  $\sqrt{\frac{mv}{qB}}$       (D)  $\frac{qB}{mv}$

23. **Bonus No. 3:** In Compton scattering, a photon scatters off a stationary electron. At which of the following scattering angles  $\theta$  will the electron receive the **least** amount of energy from the photon? (The graph of  $\cos\theta$  is shown on the right.)

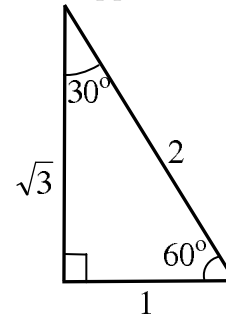


(A)  $20^\circ$       (B)  $45^\circ$       (C)  $90^\circ$       (D)  $180^\circ$

**Section B**

Name: \_\_\_\_\_

1. A charge of  $0.2\text{ C}$  is moving vertically in a field of  $4\text{ T}$  that is oriented at  $30^\circ$  from vertical (that is, the  $\vec{\mathbf{B}}$  vector makes an angle of  $30^\circ$  with respect to the vertical direction). What speed must the charge have such that the magnitude of the magnetic force acting on it is  $10\text{ N}$ ? The following triangle might be useful in calculating the speed. Also recall that  $\text{sine} = \text{opposite over hypotenuse}$ .



2. A 0.5-kg piece of metal at a temperature of  $70^{\circ}\text{C}$  is placed into 1.0-kg of water at  $20^{\circ}\text{C}$ . When the metal and water come to thermal equilibrium, both are at  $30^{\circ}\text{C}$ . The specific heat of water is  $4.2 \text{ kJ}/(\text{kg} \cdot \text{C}^{\circ})$ . What is the specific heat of the metal? (Assume that no thermal energy has escaped from the water and metal into the environment.)