

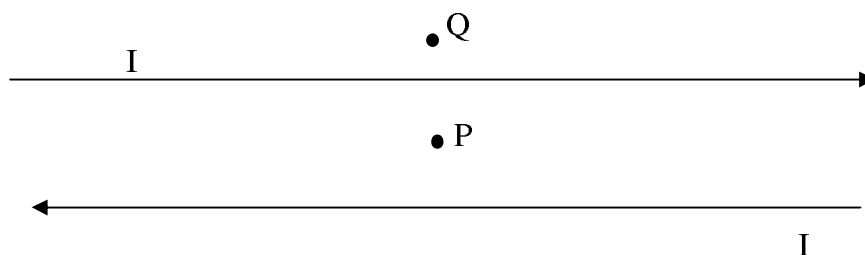
**Physics 262: Physics for Life Sciences II**  
**Third Exam**

- Time allowed: 90 minutes
- Calculators are not permitted.
- Section A contains multiple choice questions. There are 20 questions + 3 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. When the ends of two bar magnets are near each other, they repel one another. The poles of the ends that repel each other must be
  - (A) one north, the other south.
  - (B) both north.
  - (C) both south.
  - (D) either both north or both south.
2. Blood contains ions (charged particles) that can be utilized by monitoring devices. If a magnet is placed close to an artery so that the magnetic field lines are perpendicular to the direction of blood flow, the ions will experience a force that is
  - (A) perpendicular to the velocity and parallel to the magnetic field.
  - (B) parallel to the velocity and parallel to the magnetic field.
  - (C) perpendicular to the velocity and perpendicular to the magnetic field.
  - (D) parallel to the velocity and perpendicular to the magnetic field.

*The following pertains to questions 3 and 4. Assume that there are two long straight wires carrying the same magnitude of current, but in opposite directions. The arrows indicate the direction of the (conventional) current.*



3. At the point  $P$ , which is exactly half way between the two wires, in which direction is the magnetic field  $\vec{\mathbf{B}}$  pointing?
  - A) up  $\uparrow$
  - (B) into the paper  $\otimes$
  - (C) out of paper  $\odot$
  - (D)  $|\vec{\mathbf{B}}| = 0$
4. At point  $Q$ , in which direction is the magnetic field pointing?
  - (A) up  $\uparrow$
  - (B) down  $\downarrow$
  - (C) into the paper  $\otimes$
  - (D) out of the paper  $\odot$
5. Consider a situation where a uniform magnetic field is pointing out of the paper ( $\odot$ ), and an electron (which has charge  $-1.6 \times 10^{-19}$  C) is moving in the plane of the paper. If the force of the electron due to the magnetic field is to the right  $\rightarrow$ , in what direction is the electron moving?
  - (A) up  $\uparrow$
  - (B) right  $\rightarrow$
  - (C) down  $\downarrow$
  - (D) left  $\leftarrow$ .

6. What is  $50^{\circ}\text{C}$  in  $^{\circ}\text{F}$ ?  
(A)  $10^{\circ}\text{F}$  (B)  $50^{\circ}\text{F}$  (C)  $90^{\circ}\text{F}$  (D)  $122^{\circ}\text{F}$
7. A metal bar has a length of  $1.0000\text{ m}$  at  $T = 30^{\circ}\text{C}$ . When the temperature decreases to  $T = 10^{\circ}\text{C}$ , the bar shrinks to  $0.9994\text{ m}$ . What is the coefficient of linear expansion of the metal?  
(A)  $1 \times 10^{-5} / \text{C}^{\circ}$   
(B)  $2 \times 10^{-5} / \text{C}^{\circ}$   
(C)  $3 \times 10^{-5} / \text{C}^{\circ}$   
(D)  $6 \times 10^{-5} / \text{C}^{\circ}$
8. Which of the following walls (identical areas) would be the best thermal insulator (that is, for a given temperature difference which will lose the least heat)?  
(A)  $10\text{ cm}$  of wood [ $k = 0.12\text{ J}/(\text{s} \cdot \text{m} \cdot \text{C}^{\circ})$ ].  
(B)  $20\text{ cm}$  of glass [ $k = 0.84\text{ J}/(\text{s} \cdot \text{m} \cdot \text{C}^{\circ})$ ].  
(C)  $1.0\text{ m}$  of concrete [ $k = 1.3\text{ J}/(\text{s} \cdot \text{m} \cdot \text{C}^{\circ})$ ].  
(D)  $10\text{ m}$  of iron [ $k = 46\text{ J}/(\text{s} \cdot \text{m} \cdot \text{C}^{\circ})$ ].
9. A glass window conducts power  $P$  from a house to the cold outdoors when the inside is  $25^{\circ}\text{C}$  and the outside is  $15^{\circ}\text{C}$ . What is the power loss through the same window when it is  $25^{\circ}\text{C}$  inside and  $-5^{\circ}\text{C}$  outside? (Assume heat is only lost by conduction through the glass.)  
(A)  $P$  (B)  $2P$  (C)  $3P$  (D)  $9P$
10. An ideal gas is kept in a cylinder with fixed pressure. The temperature of the gas is decreased from  $27^{\circ}\text{C}$  to  $24^{\circ}\text{C}$ . The volume of the gas  
(A) decreases by about 1 percent.  
(B) increases by about 1 percent.  
(C) decreases by about 11 percent.  
(D) increases by about 11 percent.
11. The temperature of an ideal gas increases from  $27^{\circ}\text{C}$  to  $327^{\circ}\text{C}$ . What happens to the average speed of the molecules in the gas?  
(A) Increases by a factor of  $\sqrt{2}$ .  
(B) Increases by a factor of 2.  
(C) Increases by a factor of  $\sqrt{327/27}$ .  
(D) Increases by a factor of  $327/27$ .

12. When you apply heat to the bottom of a pot of water, the heat is transferred throughout the water mainly by  
(A) conduction. (B) convection. (C) radiation. (D) all three equally.
13. Two lasers emit the *same* number of photons per second. One emits blue light the other red light. Which of the following statements is true? (Remember,  $\lambda_{\text{blue}} < \lambda_{\text{red}}$ )
- (A) The power radiated by the blue laser is greater than that of the red laser.  
(B) The power radiated by the red laser is greater than that of the blue laser.  
(C) The power radiated by the blue laser and the red laser are the same.  
(D) It is impossible to determine which laser radiates with greater power.

*The following pertains to Qu. 14 and 15.* To eject electrons from a certain metal by shining light on its surface, the frequency of the light must be at least  $2 \times 10^{14}$  Hz. A photon of frequency  $2 \times 10^{14}$  Hz has energy 0.8 eV.

14. If light of frequency  $3 \times 10^{14}$  Hz is used, what is the maximum kinetic energy of electrons emitted from the metal?  
(A) 0.4 eV (B) 0.8 eV (C) 1.2 eV (D) 2.4 eV
15. If the power (energy per unit time) of the light is kept constant but the frequency of the light increases,
- (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 decreases.  
(D) the maximum kinetic energy of the ejected electrons and the rate at which the electrons are ejected both increase.
16. In order for a neon sign to emit its characteristic orange light, it is necessary that (hint: consider a neon atom to be like a hydrogen atom)
- (A) there be no unoccupied energy levels in each neon atom.  
(B) all the electrons in the neon atom be in the ground state.  
(C) the neon atoms be continually replenished with fresh atoms, because the energy of atoms is used up, which would result in dimmer and dimmer light.  
(D) the electrons in the neon atoms be given energy to raise them from their ground state to an excited state.

17. How many neutrons are there in a  $^{14}_6\text{C}$  nucleus?  
(A) 6 (B) 8 (C) 14 (D) 20
18. The radioactivity of a particular sample of radioactive material is reduced to 1/8 of its original amount after 24 days. What is the half life of the material?  
(A) 3 days (B) 4 days (C) 6 days (D) 8 days
19. In the nuclear reaction  $^{238}_{92}\text{U} \rightarrow ^{234}_{90}\text{Th} + X$ , what is  $X$ ?  
(A) an alpha particle ( $^4_2\text{He}$ ) (B) a beta-particle ( $^0_{-1}\text{e}$ )  
(C) a gamma ray (D) a positron ( $^0_{+1}\text{e}$ )
20. In order to separate an alpha particle into 2 protons and 2 neutrons, one must supply 28.3 MeV of energy to the alpha particle. What can be concluded about the mass of the alpha particle,  $m_\alpha$ , in relation to the proton mass  $m_p$  and neutron mass  $m_n$ ?  
(A)  $m_\alpha = 2m_p + 2m_n$  (B)  $m_\alpha < 2m_p + 2m_n$  (C)  $m_\alpha > 2m_p + 2m_n$   
(D) None of the above can be concluded.
21. **Bonus:** The Sun's energy production occurs near its center, and is initially in the form of very short wavelength X-ray and gamma ray photons (wavelengths  $< 10^{-10}$  m). When these photons reach the surface of the sun the wavelengths of the photons increase to approximately  $2 \times 10^{-7}$  m to  $8 \times 10^{-7}$  m due to repeated Compton scattering with electrons in the Sun. Roughly how many times on average does a photon scatter off an electron in its epic journey from the center to the surface of the Sun?  
(A)  $10^5$  (B)  $10^{12}$  (C)  $10^{17}$  (D)  $10^{21}$
22. **Bonus:** Living tissue has 16 beta decays from  $^{14}_6\text{C}$  per gram per minute. If I have a 1 kg piece of bone from a Neanderthal and I measure 1 beta decay from  $^{14}_6\text{C}$  per minute from that bone, approximately how old is the bone? The half-life of  $^{14}_6\text{C}$  is  $6 \times 10^3$  yr. (Hint:  $2^{10} \approx 1 \times 10^3$ .)  
(A)  $2.4 \times 10^4$  yr (B)  $6.0 \times 10^4$  yr (C)  $8.4 \times 10^4$  yr (D)  $2.4 \times 10^5$  yr
23. **Bonus:** A proton moves in a magnetic field that is constant in time, but varying in space. There are no other forces on the proton. Which of the following statements is true?  
(A) The speed of the proton increases when it moves into a region of stronger magnetic field.  
(B) The speed of the proton decreases when it moves into a region of stronger magnetic field.  
(C) The speed of the proton changes, but there is no simple relationship between the speed and the strength of the magnetic field.  
(D) The speed of the proton is constant.

## Section B

1. Water has a specific heat of  $4 \times 10^3 \text{ J}/(\text{kg} \cdot \text{C}^\circ)$  and latent heat of fusion of  $3.3 \times 10^5 \text{ J}/\text{kg}$ . If I mix 1.0 kg of water at  $33^\circ\text{C}$  with 1.0 kg of ice at  $0^\circ\text{C}$  in a thermally insulated container, how much ice has melted when the mixture comes to thermal equilibrium? Recall that ice melts at  $0^\circ\text{C}$ . [**Hint:** To simplify the calculation, first figure out the *algebraic expression* for the amount of ice that is melted, then insert the numbers given.]

2. For which of the following transitions in a hydrogen atom is the wavelength of the emitted light the *longest*? (1)  $n = 2$  to  $n = 1$  (2)  $n = 3$  to  $n = 1$  (3)  $n = \infty$  to  $n = 2$ . Justify your answer quantitatively (that is, with numbers).