May 3, 2006

Physics 262: Physics for Life Sciences II
Section 801: Third Midterm Test

- Time allowed: 75 minutes
- Calculators are not permitted.
- Section A contains 20 + 1 bonus multiple choice questions worth 3 points each. (Points will not be deducted for incorrect answers in this section, so you should answer all questions, even if they are complete guesses.)
- Section B has 2 problems worth 20 points each. Where appropriate, show how you obtained your answers.

Note added April 22, 2008: Questions 17 through 20 are from Chapter 29, which is not included in this year's Midterm Test 3 (but will be in the Final).

SECTION A

1. When the ends of two bar magnets are near each other, they repel one another. The poles of the ends 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

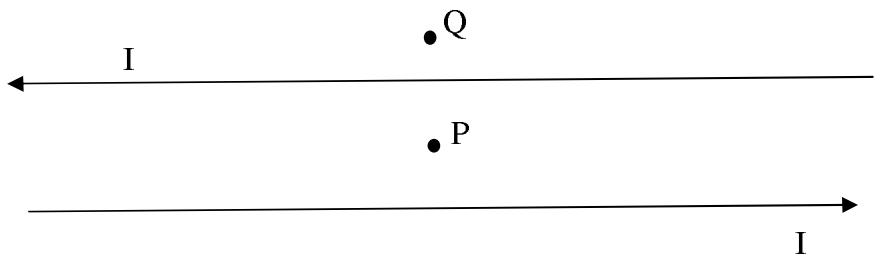
   (A) perpendicular to the velocity and parallel to the magnetic field.

   (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.



3. At the point P, which is half way between the two wires, in which direction is the magnetic field pointing?
   A) up ↑ (B) down ↓ (C) out of paper. (D) the magnetic field is zero.

4. At point Q, in which direction is the magnetic field pointing?
   (A) up ↑ (B) down ↓ (C) out of paper. (D) into the paper.

5. Consider a situation where a uniform magnetic field is pointing out of the paper ($\odot$), and a proton is moving in the plane of the paper. If the force of the proton due to the magnetic field is to the right $\rightarrow$, in what direction is the proton moving?
   (A) up $\uparrow$ (B) right $\rightarrow$ (C) down $\downarrow$ (D) left $\leftarrow$.

6. What is $50\,^{\circ}\mathrm{C}$ in $^{\circ}\mathrm{F}$?
   (A) $10\,^{\circ}\mathrm{F}$ (B) $50\,^{\circ}\mathrm{F}$ (C) $90\,^{\circ}\mathrm{F}$ (D) $122\,^{\circ}\mathrm{F}$

7. A metal bar has a length of $1.0000\,\mathrm{m}$ at $T = 30\,^{\circ}\mathrm{C}$. When the temperature decreases to $T = 10\,^{\circ}\mathrm{C}$, the bar shrinks to $0.9994\,\mathrm{m}$. What is the coefficient of linear expansion of the metal?

   (A) $1 \times 10^{-5}\,/\mathrm{C^o}$
   (B) $2 \times 10^{-5}\,/\mathrm{C^o}$
   (C) $3 \times 10^{-5}\,/\mathrm{C^o}$
   (D) $6 \times 10^{-5}\,/\mathrm{C^o}$

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 cm of wood $[k = 0.12\,\mathrm{J/(s \cdot m \cdot C^o}]$.
   (B) 20 cm of glass $[k = 0.84\,\mathrm{J/(s \cdot m \cdot C^o}))]$.
   (C) 1.0 m of concrete $[k = 1.3\,\mathrm{J/(s \cdot m \cdot C^o})]$.
   (D) 10 m of iron $[k = 46\,\mathrm{J/(s \cdot m \cdot C^o})]$.

9. A glass window conducts power P from a house to the cold outdoors when the inside is $25^{\circ}\mathrm{C}$ and the outside is $15^{\circ}\mathrm{C}$. What is the power loss through the same window when it is $25^{\circ}\mathrm{C}$ inside and $-5^{\circ}\mathrm{C}$ 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 $27\,^{\circ}\mathrm{C}$ to $24\,^{\circ}\mathrm{C}$. 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 °C to 327 °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 2×10^{14} Hz. A photon of frequency 2×10^{14} Hz has energy 0.8 eV.

14. If light of frequency 3×10^{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 frequency of the light is kept constant but the intensity 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 both increase.

    (D) the maximum kinetic energy of the ejected electrons and the rate at which the electrons are ejected both remain the same.

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 (lowest energy) 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 ${}^{14}_{6}\mathrm{C}$ 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 ${}^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + X$, what is X?
    (A) an alpha particle (B) a beta-particle (C) a gamma ray
    (D) a positron

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_α, in relation to 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 $< 10^{-10}\,\mathrm{m}$). When these photons reach the surface of the sun the wavelengths of the photons increase to approximately $2 \times 10^{-7}\,\mathrm{m}$ to $8 \times 10^{-7}\,\mathrm{m}$ 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}

Section B

1. Water has a specific heat of $4 \times 10^3\,\mathrm{J/(kg \cdot C^o)}$ and latent heat of fusion of $3.3 \times 10^5\,\mathrm{J/kg}$. If I mix 2.0 kg of water at $20\,^{\circ}\mathrm{C}$ with 1.0 kg of ice at $0\,^{\circ}\mathrm{C}$ in a thermally insulated container, how much ice is left when the mixture comes to thermal equilibrium? (You may leave your answer in the form of a fraction.)

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).