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.
SECTION A

1. If the south pole of a freely rotating compass needle points to the right (→), the direction of the magnetic field is
   (A) ↑ (B) ↓ (C) ← (D) →

2. A 2.0 C charge moving at a speed of 5.0 m/s an angle of 53° to a constant magnetic experiences a force of magnitude 16 N. What is magnitude of the magnetic field? (See triangle on the front of this test.)
   (A) 1.28 T (B) 2.0 T (C) 4.0 T (D) 25 T

The following pertains to questions 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 ⊙’s. The directions of the electric currents in both wires are out of the paper, and magnitude of the current in the right is twice that of the left. Point P is exactly half way between the two wires.

![Diagram of two wires with current I and 2I and point P] (exact diagram)

3. At point P, in what direction is the magnetic field due to these currents?
   (A) up ↑ (B) down ↓ (C) left ← (D) right →

4. What are the directions and the magnitudes of the magnetic forces that the wires exert on each other?
   (A) The wires attract each other, and the magnitude of the attractive force on each wire is the same.
   (B) The wires repel each other, and the magnitude of the repulsive force on each wire is the same.
   (C) They attract each other, and the magnitude of the attractive force on one wire is twice as large as the force on the other.
   (D) The wires repel each other, and the magnitude of the repulsive force on one wire is twice as large as the force on the other.
5. An electron (which is negatively charged) moves in the trajectory shown below due to the presence of a magnetic field. In what direction is the magnetic field pointing?

(A) up ↑  (B) down ↓  (C) out of the paper ⊙  (D) into the paper ⊗

6. A long cylindrical solenoid consists of $N$ turns of wire that are uniformly spread over a length $L$. When a current $I$ is passed through the wire a magnetic field of magnitude $B$ is produced inside the solenoid. Which of the following would double the magnitude of the magnetic field inside the solenoid with the same current?

(A) Double $N$ and keep $L$ constant.
(B) Double $L$ and keep $N$ constant.
(C) Double $N$ and double $L$.
(D) Either double $N$ and keep $L$ constant, or double $L$ and keep $N$ constant.

7. The volume of a metallic cube increases by 0.6% when the temperature is changed by 100°C. What is its thermal coefficient of linear expansion of the metal of the cube?

(A) $6 \times 10^{-3}$ °C$^{-1}$
(B) $2 \times 10^{-3}$ °C$^{-1}$
(C) $6 \times 10^{-5}$ °C$^{-1}$
(D) $2 \times 10^{-5}$ °C$^{-1}$

8. A glass of water is placed in a freezer. As the water is in the process of freezing (so that in the glass there is a mixture of water and ice),

(A) the temperature of the water/ice mixture continuously decreases.
(B) the temperature of the water/ice mixture continuously increases.
(C) heat continuously leaves the water/ice mixture.
(D) heat continuously enters the water/ice mixture.

9. An object that is at $-123$°C is placed in an environment that is at room temperature (27°C). If the power radiated (via blackbody radiation) by the object to the environment is $P$, the power of the radiation that the object absorbs from the environment is

(A) $2P$     (B) $\frac{123}{27}P$     (C) $16P$     (D) $\left(\frac{123}{27}\right)^4 P$
10. The Canadian $2$ coin is composed of two parts joined together – an outer ring and a central disk, made of different metals. Early batches of the coin had a defect which caused the central disk to drop out when the coin was exposed to extreme cold. What does this tell us about the properties of the metals of the outer ring and the central disk in these coins?

(A) The specific heat of the central disk’s metal is larger than that of the outer ring.
(B) The specific heat of the central disk’s metal is smaller than that of the outer ring.
(C) The thermal coefficient of linear expansion of the central disk’s metal is larger than that of the outer ring.
(D) The thermal coefficient of linear expansion of the central disk’s metal is smaller than that of the outer ring.

In Questions 11 and 12, assume there is no heat transferred to or from the environment. The specific heat of water is $4 \times 10^3 \text{ J/(kg }^\circ \text{C)}$ and the latent heat of vaporization of water is $2 \times 10^6 \text{ J/kg}$.

11. If we mix 1.0 kg of water at 20$^\circ$C with 2.0 kg of water at 80$^\circ$C, what is the final temperature of the water?
   (A) 30$^\circ$C  (B) 40$^\circ$C  (C) 50$^\circ$C  (D) 60$^\circ$C

12. If we mix 1.0 kg of water at 0$^\circ$C with 0.1 kg of steam at 100$^\circ$C, when the mixture comes to equilibrium it is
   (A) a mixture of steam and water at 100$^\circ$C.
   (B) all water at a temperature greater than 50$^\circ$C.
   (C) all water at a temperature of 50$^\circ$C.
   (D) all water at a temperature of less than 50$^\circ$C.

13. Two ideal gases are at the same temperature. The particles that make up gas $A$ have an average (i.e., root mean square) speed that is twice that of the particles that make up gas $B$. Which of the following statements is consistent with this?
   (A) The mass of the gas $A$ particles is half that of gas $B$.
   (B) The mass of the gas $A$ particles is a quarter that of gas $B$.
   (C) The mass of the gas $A$ particles is twice that of gas $B$.
   (D) The mass of the gas $A$ particles is four times that of gas $B$. 
14. Two thin rods, labelled 1 and 2, are made of the same material and are of lengths \( L_1 \) and \( L_2 \). The two ends of the rods have the same temperature difference, and the power of the heat conducted by the rods is the same. What is the relationship between the diameters \( d_1 \) and \( d_2 \) of the rods? (Recall that the area of a circle is proportional to the diameter squared.)

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\begin{align*}
(A) \quad \frac{L_1}{L_2} &= \left( \frac{d_1}{d_2} \right)^2 \\
(B) \quad \frac{L_1}{L_2} &= \left( \frac{d_2}{d_1} \right)^2 \\
(C) \quad \frac{L_1}{L_2} &= \sqrt{\frac{d_1}{d_2}} \\
(D) \quad \frac{L_1}{L_2} &= \sqrt{\frac{d_2}{d_1}}
\end{align*}
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15. Convection occurs in

(A) solids. (B) fluids. (C) vacuums. (D) all three of the above.

16. How can astronomers determine the surface temperature of a distant star?

(A) They send space probes with specially designed thermometers to orbit the star at a safe distance, and extrapolate the temperature on the surface from those measurements.

(B) They measure the brightness of the star (i.e., how much electromagnetic energy reaches the Earth).

(C) They measure the electromagnetic spectrum of the light emitted by the star and use Wien’s law.

(D) They just make up a number – after all, who can tell if they’re wrong?

17. In a photoelectric effect experiment, light of frequency \( f \) is shone onto a metallic surface and electrons are ejected from the metal. The maximum kinetic energy of the electrons is \( K \). If light of frequency \( 2f \) is used instead on the same metal, the maximum kinetic energy of the ejected electrons

(A) is less than \( 2K \).

(B) is \( 2K \).

(C) is more than \( 2K \).

(D) can be less than, equal to or more than \( 2K \).

18. In the nuclear fission reaction \( ^{235}_{92} \text{U} \rightarrow ^{141}_{56} \text{Ba} + ^{92}_{36} \text{Kr} + X \), what is \( X \)?

(A) A proton

(B) A neutron and an electron

(C) A proton and a neutron

(D) Two neutrons
19. After two half-lives, the sample of a radioactive material (assume that the radioactive material decays into a non-radioactive material.)

(A) has its half-live reduced by half of its original value.
(B) is no longer radioactive.
(C) has its radioactivity reduced by half of its original value.
(D) has its radioactivity reduced by three-quarters of its original value.

20. Which of the following graphs best describes the radioactivity of a sample of radioactive material. (Assume that the radioactive material decays into a non-radioactive material.)

21. **Bonus (more challenging):** The Compton effect can occur for scattering of a photon from any charged particle. Compared to the Compton wavelength for an electron, the Compton wavelength for a proton (hint: try to think about how a heavier particle would affect the conservation of energy and momentum.)

(A) is the same.  (B) is longer.  (C) is shorter.
(D) could be longer, shorter or the same.
Section B

1. An ideal gas in a container of fixed volume has pressure $1.0 \times 10^5$ N/m$^2$ at temperature of 27°C. What is the pressure of the gas when the temperature is 327°C? (Use $T_{\text{Kelvin}} = 273 + T_{\text{oC}}$.)
2. For which of the following transitions in a hydrogen atom is the wavelength of the emitted light is shorter? (a) \( n = 3 \) to \( n = 2 \) or (b) \( n = \infty \) to \( n = 3 \). Justify your answer quantitatively.

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\text{Note: } \frac{1}{a} - \frac{1}{b} = \frac{b - a}{ab}. \quad \text{Also, to compare the relative sizes of fractions, manipulate the fractions so that they have the same denominator (number at the bottom) and compare the numerators.}
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