Tfy-3.1394 Physics IIB **Exam 13.05.2009**

Calculators are allowed

Choose and answer 5 questions out of 6.

1. You sight along the rim of a glass with vertical sides so that the top rim is lined up with the opposite edge of the bottom (see Figure 1). The glass is a thin-walled hollow cylinder 16.0 cm high with a top and bottom of the glass diameter of 8.0 cm. While you keep your eye in the same position, a friend fills the glass with a transparent liquid, and you the see a dime that is lying at the center of the bottom of the glass. What is the index of refraction of the liquid?

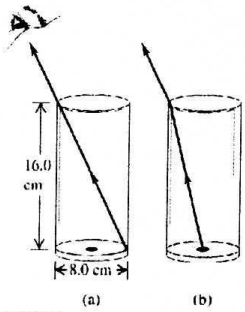

Figure 1

2. A lens forms an image of an object. The object is 16.0 cm from the lens. The image is 12.0 cm from the lens on the same side as the object. a) What is the focal length of the lens? Is the lens converging or diverging? b) If the object is 8.50 mm tall, how tall is the image? Is it erect or inverted? c) Draw a principal-ray diagram.

3. An electron accelerated by 0.420 MV potential difference in an x-ray tube strikes an anode. When it arrives at the anode, what is a) its kinetic energy in eV? b) its total energy in eV? c) its speed? d) What is the speed of the electron, calculated classically?

4. A diatomic molecule is modeled as a harmonic oscillator with mass $5.60 \cdot 10^{-26}$ kg and force constant 12.0 N/m. a) If the oscillator undergoes a transition from $n = 4$ to $n = 3$ level by emitting a photon, what is the wavelength of this photon? b) What is the ground state energy (in eV) of this oscillator?

5. If a photon and an electron have the same de Broglie wavelength, will they have the same kinetic energy? If so, show why. If not, find the ratio of the proton's kinetic energy to that of the electron.

6. What is the probability of finding a particle in a box of length L in the region between $x = L/4$ and $x = 3L/4$ when the particle is in a) the ground level; b) the first excited level? (Hint: Integrate $|\psi(x)|^{2dx}$, where ψ is normalized, between $L/4$ and $3L/4$.) c) Are your results in parts (a) and (b) consistent with Figure 2? Explain.

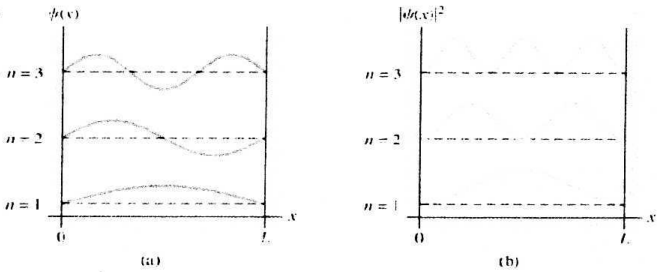

Figure 2

$e = 1.60 \cdot 10^{-19}$ *C*, $m_e = 9.11 \cdot 10^{-31}$ kg, $h = 6.63 \cdot 10^{-34}$ J·s, $c = 3.00 \cdot 10^{8}$ m/s