Arts & Science 2D06

Quiz #7 2008 Mar 14 **Name:**

NB: Mark values are given in brackets [ ] beside each problem. Write all your answers on the quiz paper. No books or notes allowed. Time to write quiz: 50 minutes.

Wave equation: $y = A\ \sin(kx - \omega t + \varphi)$ where $k = 2\pi/\lambda$

Photon energy: $E = hc/\lambda$

Energy levels of H atom: $E_n = -13.6eV/n^2$

Wavelengths emitted by H atom: $\frac{1}{\lambda_n} = R(\frac{1}{n^2} - \frac{1}{m^2})$

de Broglie relation: $\lambda = h/p$

1 eV = 1.6×10^{-19}J

Speed of light $c = 3.00 \times 10^8$ m/sec
Planck's constant $h = 6.626 \times 10^{-34}$ J-sec and $\hbar = h/(2\pi)$
Rydberg constant $R = 1.097 \times 10^7$ m^{-1}
Mass of electron $m_e = 9.11 \times 10^{-31}$ kg
Mass of proton $m_p = 1.67 \times 10^{-27}$ kg

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1. [2] Suppose that the intensity of a light beam is increased, but its frequency is left unchanged. Which of the following statements about the photons in the light beam is true? (Explain your answer.)

(a) The photons move faster.
(b) Each photon has more energy than before.
(c) The photons become larger.
(d) The beam contains more photons per second

2. [3] The picture below shows a circular standing wave, corresponding to a quantum state of the hydrogen atom. What is the "quantum number" n of this state? (Explain your answer.)

3. [5] For what wavelength of light does a 100 mW laser deliver 2.6×10^{17} photons per second? (1 mW = 10^{-3} J/s)

4. [5] If a proton and an electron have the same (non-relativistic) kinetic energies, which of the two particles has the shorter wavelength?

5. [5] A hydrogen atom with its electron in the ground state absorbs a photon with an energy of 12.75 eV. Immediately after this absorption, the electron undergoes another "quantum jump" to the energy level directly below. What is the wavelength of the photon emitted in this second jump?

[20] total marks