Arts & Science 2D06

Quiz #7 2014 Mar 25 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.

Photon energy: $E = hc/\lambda$

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

Infinite square well: $E_n = (h^2/8mL^2)n^2 \qquad \psi(x) = A \sin(n\pi x/L)$

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

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

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 (or neutron) $m_p = 1.67 \times 10^{-27}$ kg
1 $MeV = 1.6 \times 10^{-13}$J

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1. [3] As a particle travels faster and faster, its de Broglie wavelength:

(Explain/derive your answer.)

a) increases.
b) decreases.
c) remains constant.
d) could be any of the above; it depends on other factors.

2. [3] The energy difference between adjacent orbit radii in a hydrogen atom:

(Explain/derive your answer.)

a) increases with increasing values of n.

b) decreases with increasing values of n.

c) remains constant for all values of n.

d) varies randomly with increasing values of n.

3. [4] An electron inside a hydrogen atom is confined to a region of space of 0.11 nm wide. Under these conditions, what is the uncertainty in the electron's velocity?

4. [2+2+2] A proton finds itself trapped in an infinitely deep square well potential (a.k.a. one-dimensional box), of width L.

a) If the ground state energy is 4 MeV, what is the smallest amount of energy that the proton can absorb?

Suppose now that the proton is in the third excited state:

b) Sketch the proton's wavefunction. Where inside the well/box will the particle never be found?

c) Suppose you measure the particle's position. What is the probability that the proton will be found in the region between $x > L/4$ and $x < 3L/4$? Justify your answer.

5. [4] Suppose a 60-W light-bulb converts 6.2% of its input energy into visible light of wavelength 580 nm. How many (visible) photons per second does the bulb emit? (1 W = 1 J/sec)

[20] total marks