INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

SCIENCE I

SC1110 Monsoon 2020

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Problem Set - III

Date of Submission: November 21, 2020 21:00 HRS

Q1. A transmitter is rated 1 kW when operating at 980 kHz. How many photons per second does this radio emit ?

Q2. Given that maximum wavelength for photoelectric emission for tungsten is 230 nm, for the ejected electrons to have a energy of 1.5 eV, what should be the wavelength of the light used?

Q3. Given monochromate light source (wavelength 65.8 pm) is scattered through an angle of 46°, estimate the wavelength of the scattered beam.

Q4. Find deBroglie wavelength of a 250 gm cricket ball bowled at a speed of 21 yards/sec.

Q5. Two travelling waves having angular frequency ω and $\omega + \Delta\omega$ and wave vector k and $k + \Delta k$ interfere/superimposed. What is the group velocity and phase velocity of the resulting wave ? Show schematic diagrams to illustrate both.

Q6. If Planck constant is smaller than its value, what do you think the world will look like? (Max 5 sentences)

Q7. An atomic nucleus is estimated to be 10^{-15} m in radius

(a) Estimate the minimum kinetic energy of the proton inside nucleus.

(b) Estimate the lower limit on energy an electron must have if it were to be part of nucleus.

Q8. (a) An excited atom gives off a photon to reach its ground state. It is estimated that the average time of 10^{-8} sec separates the excitation of atom and consequent emission of photon. Estimate the inherent uncertainty in frequency of the emitted photon.

(b) If this emitted photon is from an hydrogen atom in hydrogen atom gas, at equilibrium, at 300 K, what is the Doppler shift in frequency?

(c) Compare uncertainty in (a) with the shift in (b).

Q9. In classical model of atom, find the frequency of revolution of electron in hydrogen atom. What will be the color of photon of this frequency?

Q10. When an excited atom emits photon a portion of energy difference goes into recoil of the atom. Find the ratio of recoil energy and photon energy for $n = 3$ to $n = 2$ transition of Hydrogen atom.

Q11. For laser action, the lasing atom must have at least three energy levels. Why?

Q12. Solve for a particle in 3D Box of length L.

(a) What are energy levels?

(b) Find the normalised wave functions for stationary states.

(c) For first few low energy levels draw energy level diagram, explicitly showing the degeneracy.

(d) When $E \gg E_{\text{ground state}}$, find number of energy levels between E and $E + dE$, i.e., degeneracy $g(E)$. Plot $g(E)$ vs E.

Q13. For a particle in 1D box, you are told that the particle is prepared in superposition of $n = 1$ and $n = 2$ state. What is the wavefunction? If the experiment is done 1000 times starting with identically prepared system each time, what would be the average position and energy of the particle.

Q14. You are told that for the particle in 1 D box, the wave function is given by $\phi(x) \propto x(L-x)$. Find

(a) Expectation value of position, and uncertainty in position.

(b) Expectation value of energy

Q15. Find the tunneling probability for a particle going facing a barrier of E_0.

Q16. For the Hydrogen atom, hand draw the energy level diagram and shape of orbitals.