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NATIONAL INSTITUTE OF TECHNOLOGY GOA

Department of Applied Sciences

Programme Name: B.Tech

End Semester Examination, April-2020

Course Name: Physics | Course Code: PH100

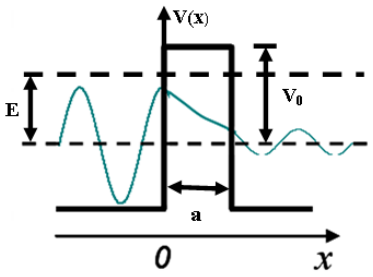
Date: 12/04/2021 | Time: 9.30 – 12.30 pm

Duration: Three Hours | Max. Marks: 100

ANSWER ALL QUESTIONS

1. Explain tunneling through a barrier? A particle travelling with energy E along X-axis has a potential barrier defined as (10M)

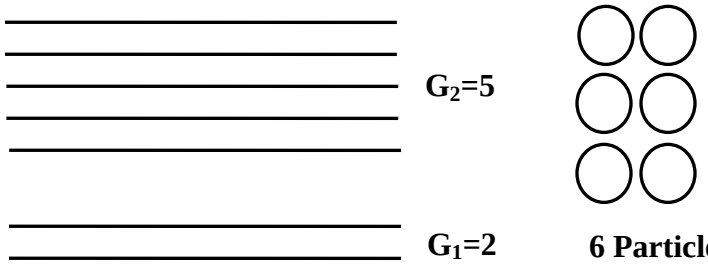
V(x)=0 for x<0
V(x)= V_0 for 0 < x < a
V(x)=0 for x<a



Derive the expressions for the Reflection and transmission coefficients of the particle by assuming width of the barrier **a=0 and E>V_0**. Where E is the total energy of the particle and **a** is the width of the barrier.

2. From a sodium surface, light of wavelength 3125 Å and 3650 Å causes emission of electrons whose maximum kinetic energy is 2.128 eV and 1.595 eV, respectively. Estimate Plank's constant and work function of sodium. (5M)
3. X-rays with $\lambda = 1.0$ Å are scattered from a metal block. The scattered radiations are viewed at 90º to the incident direction. Evaluate the Compton shift. ($h = 6.626 \times 10^{-34} js$ *and* $m = 9.1 \times 10^{-31} kg$) (4M)
4. How particle nature of radiation was confirmed by the photoelectric effect and Compton Effect? (4M)
5. Calculate the de Broglie wavelength of an electron having a kinetic energy of 1000eV. Compare the result with the wavelength of X-rays having the same energy. (5M)
6. The speed of an electron is measured to be $5.0 \times 10^3\ m/s$ to an accuracy of 0.003%. Find the minimum uncertainty in determining the position of this electron. (5M)
7. The average lifetime of an excited atomic state is $10^{-9} s$. If the spectral line associated with the decay of this state is 6000 Å, estimate the width of the line. (7M)
8. A particle constrained to move along X-axis in the domain $0 \leq x \leq L$ has a wave function $\psi(x) = \sin\left(\frac{n\pi x}{L}\right)$, where *n* is an integer. Normalize the wave function and evaluate the expectation value of its momentum. (6M)
9. Prove that the velocity of a particle and the velocity of the corresponding wave packet are the same. (4M)
10. In the photoelectric effect, explain why the stopping potential depends on the frequency of light but not on the intensity. (3M)
11. A particle of mass *m* is confined to a one-dimensional box between *x=0* and *x=L*. Find the expectation value of the position *x* of the particle in the state characterized by quantum number *n*. (5M)

12.



Above figure contains 6 distinguishable particles, 2 energy levels (one with a degeneracy of 2 and the other degeneracy of 5). Calculate the number of Macrostates and microstates in this system. (5M)

13. State and discuss the behavior of Fermi-Dirac distribution function under the following conditions. (5M)
    i) $\varepsilon = 0$
    ii) $\varepsilon \ll \frac{\varepsilon_f}{kT}$.
    iii) $\varepsilon \gg \frac{\varepsilon_f}{kT}$

14. Solve the following problems using Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac statistics (Find the number of ways we can arrange the particles in a given cells) (5M)
    i) Ten Particles and eleven Cells
    ii) Three Particles and five Cells
    iii) Five Particles and three Cells
    iv) Ten Particles and thirteen Cells
    v) Eight Particles and eight Cells
15. Explain the different types of optical fibers, along with the refractive index profile and mode propagation sketches. (4M)
16. Explain the construction and working of He-Ne laser with the help of energy level diagram. (5M)
17. Calculate number of photons emitted per second by a 5m W laser emitting radiation of wavelength 6328 Å. If the beam is allowed to fall normally on an ideal plane mirror, calculate the force acting on the mirror. (5M)
18. Calculate the ratio of the rate of spontaneous emissions to the rate of stimulated emissions for a pair of energy levels. (4M)
19. An optical fiber has Numerical Aperture (NA) of 0.20 and a cladding refractive index of 1.59. Determine the acceptance angle for the fiber in water which has a refractive index of 1.33. (4M)
20. For a Thermo siphon (solar water heater), briefly explain with the help of a diagram (5M)
    i) How conductive, radiative, and convective losses are minimized
    ii) The mechanism of natural circulation is facilitated

****** All the best******