বিদ্যাসাগর বিশ্ববিদ্যালয়

VIDYASAGAR UNIVERSITY

B.Sc. Honours Examination 2021

(CBCS)

4th Semester

PHYSICS

PAPER—C9T & C9P

ELEMENTS OF MODERN PHYSICS

Full Marks : 60

Time : 3 Hours

The figures in the right-hand margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

THEORY : C9T

Answer any *two* questions.   2×15

1. (a) Deduce the expression for the Compton shift. Estimate its highest value. Show graphically how does shift change with scattering angle.

   (b) X-ray of wavelength $0.712 \overset{\circ}{A}$ collide with Carbon scatter. If the scattering particle is an electron, what will be the wavelength of the scattered X-ray in the direction of 90° ? What happens if the scattering agent is the whole carbon atom ?

(c) Write de Broglie's relation. Distinguish between macroscopic regime where classical Newton's law of motion is applied and microscopic regime where quantum mechanics to be applied in terms of de Broglie wavelength and dimension of the moving particle.

(d) Establish Bohr's angular momentum quantization condition using de Broglie's relation. (4+1+2)+3+2+3

2. (a) A wave packet is formed by superposition of two harmonic waves of frequencies ω and $\omega + d\omega$ and propagation vectors k and $k + dk$. Find the extension Δx of the wave packet and hence obtain the uncertainty principle of position-momentum conjugate pair. What happens to the extension Δx, if there is superposition of infinite number of waves having continuous distribution of wavelengths?

(b) Explain the non-existence of electron in a nucleus from Heisenberg's Uncertainty Principle.

(c) Explain the origin of broadening of spectral lines from HUP of energy-time.

(d) What are Max Born's interpretations of wavefunction?

(e) Why is normalization of wavefunction required?

(f) Find the eigen function of the operator $\left(x + \dfrac{d}{dx} \right)$ in terms of eigen value λ. (3+1)+2+2+2+2+3

3. (a) Solve the time-independent Schrodinger equation for a particle in a one dimensional box with rigid boundaries. Normalize the wave functions and prove that they are orthogonal. Explain why the energy levels are discrete in this case even though the particle is not acted upon by a potential.

(b) Let ψ_1, ψ_2, and ψ_3, are three solutions of a degenerate state of energy E. Prove that if the solutions are lineraly independent, their linear combination is also a solution having same energy value.

$(5+2+2+2)+4$

4. (a) What do you mean by nuclear fission ? In what important respect it differs from an ordinary nuclear reaction ? Explain briefly the principle of operation of a nuclear reactor.

(b) If U-236 nucleus is fissioned by a neutron, two fission fragments of mass numbers 96 and 138, and two neutrons are obtained. If the masses of the nuclei and neutron are 235.1175, 95.9385, 137.9487, and 1.00898 amu, calculate the amount of energy released.

(c) Describe the liquid drop model of the nucleus. Point out its usefulness and limitations in understanding the nuclear phenomena.

$(2+2+3)+2+(4+2)$

Answer any *one* question. 1×10

5. (a) What do you mean by "photoelectric effect" ? Ultraviolet light of wavelength 350nm and intensity 1.00 W/m^2 is directed at a potassium surface. Find the maximum KE of the photoelectrons.

(b) Write down the de Broglie hypothesis. Discuss the Davisson-Germer's experiment for experimental evidence of matter waves.

$(2+2)+(1+5)$

6. (a) What is radioactivity ? Define the decay constant λ of a radioactive material. Hence obtain an expression for the number of radioactive atoms at time t, given that their initial number was N_0. Define half-life of a radioactive element.

(b) The half-lives of radium and radon are 1622 years and 3.825 days. What is the volume of radon gas at N.T.P. equivalent to one curie ?

$(1+1+3+2)+3$

PRACTICAL : C9P

Answer any *one* question. 1×20

1. Describe with proper circuit diagram, the theoretical basis of the Planck constant measurement using a filament bulb.

   How can you determine Planck's constant utilizing Photoelectric Effect ? Draw circuit diagram. Also draw ideal $V_s \sim \upsilon$ variation indicating its slope and υ_o. 10+10

2. How can we draw $I - V$ characteristics curve of a Tunnel diode ? Draw circuit diagram. Also draw ideal $I - V$ curve indicating its peak and valley points.

   How can you determine work function of the material of filament of directly heated vacuum diode ? Deduce the formula you use.

   10+10

3. How can you determine the wavelength of a given laser light using plane diffraction grating ? Deduce the formula you use.

   How can you determine the wavelength of a given laser light using single slit diffraction pattern ? 10+10

[Internal assessment – 10]

[Attendance – 5]

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