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B.Sc./5th Sem (G)/PHS/22(CBCS)

2022

5th Semester Examination

PHYSICS (General)

Paper : DSE - 1A/2A/3A-T

[CBCS]

Full Marks : 40

Time : Two Hours

*The figures in the margin indicate full marks.
Candidates are required to give their answers
in their own words as far as practicable.*

[Elements of Modern Physics]

Group - A

Answer any *five* of the following questions : $2 \times 5 = 10$

1. Discuss briefly the wave nature of matter and obtain an expression of de Broglie wavelength for matter waves.
2. Write down the postulates of Bohr's atomic model.
3. Show that the de Broglie wavelength associated with an electron of energy V electron volts is approximately $(1.227 / \sqrt{V}) \text{ nm}$.
4. Write down the physical interpretations of wave function.
5. How does a particle with energy lower than the barrier height, tunnel through it? Give one example.
6. What is the relation between the mass number and radius of a nucleus? Calculate the radius of a ^{238}U nucleus. Given that $r_0 = 1.4 \text{ fm}$.

P.T.O.

(2)

7. What is Pauli's neutrino hypothesis?

8. What is nuclear chain reaction?

Group - B

Answer any **four** from the following questions : $5 \times 4 = 20$

9. Write down the characteristics of photo electric effect.
Write down the Einstein's equations for the explanation
of photo electric effect. 3+2

10. Discuss the hypothetical γ -ray microscope experiment
related to Heisenberg's uncertainty relation. 5

11. Prove the nonexistence of electron in the nucleus on the
basis of uncertainty principle. The lifetime of an excited
state of an atom is about 10^{-8} sec. Calculate the
minimum uncertainty in the determination of the energy
of the excited state. 3+2

12. Prove that the wave function $\psi(x) = Ae^{iKx}$ is an eigen
function of the momentum operator. K = Propagation
constant. Normalize the wave function given below to
find out the Constant 'A' for the Gaussian wave packet
given as :

$$\psi(x) = Ae^{-\frac{\alpha^2 x^2}{2}} e^{iKx} \text{ given that } \int_{-\infty}^{+\infty} e^{-\alpha^2 x^2} dx = \sqrt{\frac{\pi}{\alpha^2}}.$$

3+2

13. What do you mean by mass defect and packing fraction?
Discuss the variation of packing fraction with mass
number with the help of graph. 3+2

14. Write down the semi-empirical mass formula for the
binding energy of a nucleus of an atom. Explain each
term. 1+4

Group - C

Answer any **one** of the following questions :

10×1=10

15. (i) What do you mean by mean-life and half-life of a radioactive substance? Established the relation between them.
- (ii) When Beryllium (${}_4\text{Be}^9$) is bombarded with alpha particles, neutron is obtained. Write the equation of the process.
- (iii) Using the Bohr's postulates find out the expression for radius of n^{th} orbit and energy of the electron in this orbit of a hydrogen like atom. (2+2)+2+4
16. (a) What do you mean by nuclear binding energy? Discuss the variation of binding energy per nucleon with mass number with the help of binding energy curve. 2+3
- (b) Discuss nuclear fission and nuclear fusion with equations. 3+2

বঙ্গানুবাদ

বিভাগ - ক

নিচের যে কোনো **পাঁচটি** প্রশ্নের উত্তর দাও। 2×5=10

- পদার্থের তরঙ্গ প্রকৃতি সংক্ষেপে আলোচনা করো এবং পদার্থ তরঙ্গের জন্য ডি ব্রোগলি তরঙ্গদৈর্ঘ্যের একটি অভিব্যক্তি নির্ণয় করো।
- বোরের পরমাণু তত্ত্বের স্বীকার্যগুলি লেখো।
- দেখাও যে, V electron volts শক্তি সম্পন্ন একটি ইলেকট্রনের সঙ্গে জড়িত ডি ব্রোগলি তরঙ্গদৈর্ঘ্য প্রায় $(1.227/\sqrt{V}) \text{ nm}$ ।

P.T.O.

OR

[Mathematical Physics]1. Answer any **five** from the following : $2 \times 5 = 10$

- (i) Write down order and degree of the differential equation

$$\left(\frac{d^2 y}{dx^2} \right)^3 = \left(1 + \frac{dy}{dx} \right)^{\frac{1}{2}}$$

- (ii) State the Dirichlet's conditions for a Fouries series.

- (iii) Using de Moiver's theorem, express
- $\sin 3\theta$
- and
- $\cos 3\theta$
- in terms of powers of
- $\cos \theta$
- and
- $\sin \theta$
- .

- (iv) Show that
- $\sqrt{n+1} = n\sqrt{n}$
- .

- (v) Find the singularity of the function
- $f(z) = \sin(\frac{1}{z})$
- .

- (vi) Show that
- $(1 - 2xt + t^2)^{\frac{1}{2}}$
- is the generating function of legendre's polynomial
- $P_n(x)$
- .

- (vii) Find the particular integral (P.I) of

$$\frac{d^2 y}{dx^2} + y = \cos 2x.$$

- (viii) Show that
- $\operatorname{erf}(-x) = -\operatorname{erf}(x)$
- .

2. Answer any **four** from the following : $5 \times 4 = 20$

- (i) Laplace equation in spherical polar co-ordinates for a problem with azimuthal symmetry is given by

$$\frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial u}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial r} \left(\sin \theta \frac{\partial u}{\partial \theta} \right) = 0$$

Let $u(r, \theta) = R(r)\Theta(\theta)$, taking separation constant to be $l(l+1)$, solve for $R(r)$. Also show that substituting of $\mu = \cos \theta$ in the angular part leads to Legendre's equation for $\Theta(\theta) = P(\mu)$.

(ii) Express $f(x) = 4x^3 + 6x^2 + 7x + 2$ in terms of Legendre polynomial. 5

(iii) Find the Fourier series expansion of the periodic function of period 2π .

$$\text{Given } f(x) = x^2; \quad -\pi \leq x \leq \pi$$

Plot $f(x)$ versus x .

Hence find the sum of the series

$$\frac{1}{1^2} - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} \dots = \frac{\pi^2}{12} \quad 2+1+2=5$$

(iv) Deduce the relation between beta and gamma

$$\text{function } \beta(l, m) = \frac{\sqrt{l} \sqrt{m}}{\sqrt{l+m}}. \quad 5$$

(v) Solve the differential equation 5

$$(xy \sin xy + \cos xy)y dx + (xy \sin xy - \cos xy)x dy = 0$$

(vi) Write down the expression for Bessel's function

$$J_n(x). \text{ Prove that } J_{-n}(x) = (-1)^n J_n(x). \quad 1+4=5$$

P.T.O.

3. Answer any **one** from the following : 10×1=10

(i) (a) Evaluate the complex integral of $f(z) = z^{-1}$ along the circle $|z| = R$, starting and finishing at $z = R$.

(b) Prove that if a function $f(z)$ is analytic and its derivative $f'(z)$ is continuous at all points inside and on a simple closed curve 'C', then $\oint_C f(z) dz = 0$. 5+5=10

(ii) (a) Show that $\int_{-1}^{+1} P_n(x) P_m(x) dx = \frac{2}{2n+1} \delta_{nm}$

(b) Solve the wave equation

$$\frac{\partial^2 u(x,t)}{\partial x^2} = \frac{1}{c^2} \frac{\partial^2 u(x,t)}{\partial t^2}; \text{ under the condition}$$

$$u(x,t) = 0 \text{ when } x = 0 \text{ and } x = \pi;$$

$$\frac{\partial u(x,t)}{\partial t} = 0 \text{ when } t = 0 \text{ and}$$

$$u(x,0) = x \text{ for } 0 < x < \pi. \quad 4+6=10$$

বঙ্গানুবাদ

1. যেকোনো পাঁচটি প্রশ্নের উত্তর দাও : 2×5=10

(i) $\left(\frac{d^2 y}{dx^2} \right)^3 = \left(1 + \frac{dy}{dx} \right)^{\frac{1}{2}}$ এই অবকল সমীকরণটির ক্রম ও ঘাত নির্ণয় কর।

OR

[Quantum Mechanics]Answer any *five* from the following : $2 \times 5 = 10$

1. (a) Give the physical significance of wave function. 2
- (b) What do you mean by eigen functions and eigen value? 2
- (c) What is uncertainty in position and momentum? 2
- (d) (i) Write Pauli's exclusion principle.
- (ii) What is gyromagnetic ratio? 1+1
- (e) For $l = 0$, $s = \frac{1}{2}$, Find Lande splitting factor. 2
- (f) (i) Write whether magnetic field is high or low in case of normal zeeman effect.
- (ii) Write whether magnetic field is lower high in case of anomalous zeeman effect. 1+1
- (g) What is 'zero point energy' in simple Harmonic oscillator? 2
- (h) Write Schrödinger equation in case of free particle. 2

Answer any *four* from the following : $5 \times 4 = 20$

2. (a) (i) Write one dimensional time dependent Schrödinger equation. Write its complex conjugate. $2\frac{1}{2}$
- (ii) Find x component of momentum operator from the equation $\psi = A e^{i/\hbar}(p_x x - Et)$. $2\frac{1}{2}$

(b) (i) Prove that x , px do not commute. Find its value.

(ii) Write kinetic energy operations. 4+1

(c) (i) What do you mean by stationary states. Write probability current density in one dimension.

1+2

(ii) Find if $\frac{\partial}{\partial x}$ and $\frac{\partial^2}{\partial x^2}$ commute. 2

(d) (i) Find zero point energy in case of one dimensional linear harmonic oscillator of frequency $5 \times 10^{14}/\text{sec}$.

$$\left[\hbar = 1.05 \times 10^{-27} \text{ unit} \right]$$

(ii) Sketch potential of Harmonic oscillator. 3+2

(e) What is L-S coupling? What is J-J coupling?

$2\frac{1}{2} + 2\frac{1}{2}$

(f) (i) Find the expression of Bohr magneton. Write its unit.

(ii) Derive total angular momentum for f-electron.

2+3

Answer any *one* question : $10 \times 1 = 10$

3. (a) (i) Draw the sketch of Stern-Gerlach experiment.

2

(ii) Why silver atom is taken?

2

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(iii) How inhomogeneous magnetic field is given? 2

(iv) Write n, l, ml, ms for L-shell. 2

(v) Give the outcome of Zeeman Effect. 2

4. (a) $\Psi_n(x) = A \sin \frac{n\pi x}{a}, 0 < x < a$

Find normalized wave function. 3

(b) Write time independent Schrödinger equation in case of square well potential. Find energy. Give energy level diagram. 5+2

বঙ্গানুবাদ

যেকোনো পাঁচটি প্রশ্নের উত্তর দাও। 2×5=10

1. (a) তরঙ্গ অপেক্ষকের ভৌত ব্যাখ্যা দাও। 2

(b) আইগেন অপেক্ষক ও আইগেন মান কি? 2

(c) স্থান ভরবেগ অনিশ্চয়তা কি? 2

(d) (i) পাউলির অপবর্জন নীতি লেখ। 1+1

(ii) গাইরো ম্যাগনেটিক অনুপাত কি?

(e) $l = 0, s = \frac{1}{2}$, Lande splitting factor $g = ?$ 2

(f) (i) Normal Zeeman Effect-এ চৌম্বক ক্ষেত্রের তীব্রতা বেশি না কম?

(ii) Anomalous Zeeman Effect-এ চৌম্বক ক্ষেত্রের তীব্রতা বেশি না কম? 1+1

OR

[Medical Physics]**Group - A**Answer any *five* from the following : $2 \times 5 = 10$

1. (a) Write down two examples of first class lever in human body.
- (b) Write down the chemical reaction for oxidation of 1 mol of glucose by 6 mol of oxygen molecules, which takes place during metabolism. How much energy is produced in this reaction.
- (c) Why does the body convert food fuel to ATP and not directly oxidize carbohydrates, fatty acids, and proteins? 2
- (d) Write down typical frequency range of hearing and the frequency range of ultrasound. 2
- (e) What is biological half-life? 2
- (f) What is the role of tendon? 2
- (g) State the purpose Atomic Energy Regulatory Board (AERB). 2
- (h) What is radioisotope imaging? 2

Group - BAnswer any *four* from following : $5 \times 4 = 20$

2. (a) The mass attenuation coefficient of bone with a density of 1.8 g cm^{-3} is $0.2 \text{ cm}^2 \text{g}^{-1}$ for an 80 keV

P.T.O.

gamma ray. Calculate the percentage of a photon beam attenuated by 5 cm thickness of bone.

- (b) If Tc-99m with a physical half-life of six hours is used to radio-label a compound that clears from the body with a biological half-life of four hours, what is the effective half-life of the radio pharmaceutical?
- (c) Compare Compton effect with photoelectric effect.
- (d) Compare scintillation counter with Geiger Muller counter.
- (e) Explain the working principle of USG
- (f) Compare the principles of image formation between projection X-ray and gamma scintigraphic imaging.

Group - C

Answer any *one* from the following : $10 \times 1 = 10$

3. (a) What is fluoroscopy? Describe the experimental set up. Compare photoconductive video cameras with CCD video cameras. 3+5+2
- (b) Discuss the working principle of Doppler test. How does the continuous wave system of Doppler ultrasound device work? What are the main features? Compare this with pulsed wave doppler. 3+3+2+2