Indian Forest Service Examination, 2013

A–JGPT–M–QIZ–B

PHYSICS

PAPER—II

(CONVENTIONAL)

Time Allowed : Three Hours	Maximum Marks : 200

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions

There are EIGHT questions in all out of which FIVE are to be attempted.

Question Nos. **1** and **5** are compulsory. Out of the remaining SIX questions, THREE are to be attempted selecting at least ONE question from each of the two Sections A and B.

Attempts of questions shall be counted in chronological order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

All questions carry equal marks. The number of marks carried by a question/part is indicated against it.

Answers must be written in ENGLISH only.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary and indicate the same clearly.

Neat sketches may be drawn, wherever required.

List of Useful Constants :

Mass of proton	$= 1 \cdot 673 \times 10^{-27}$ kg
Mass of neutron	$= 1 \cdot 675 \times 10^{-27}$ kg
Mass of electron	$= 9 \cdot 11 \times 10^{-31}$ kg
Planck constant	$= 6 \cdot 626 \times 10^{-34}$ Js
Boltzmann constant	$= 1 \cdot 380 \times 10^{-23}$ JK^{-1}
Bohr magneton	$= 9 \cdot 273 \times 10^{-24}$ $A\,m^2$
Nuclear magneton (μ_N)	$= 5 \cdot 051 \times 10^{-27}$ $JT^{-1}(Am^2)$
Electronic charge	$= 1 \cdot 602 \times 10^{-19}$ C
Atomic mass unit (u)	$= 1 \cdot 660 \times 10^{-27}$ kg = 931 MeV

$g_s^p = 5 \cdot 5855\,\mu_N$ $\qquad$ $m(p) = 1 \cdot 00727$ u

$m(n) = 1 \cdot 00866$ u $\qquad$ $m(^4_2\text{He}) = 4 \cdot 002603$ u

$m(^{12}_6\text{C}) = 12 \cdot 00000$ u $\qquad$ $m(^{87}_{38}\text{Sr}) = 86 \cdot 908893$ u

SECTION—A

1. *(a)* The particle in a box has a ground state wave function given as

$$\psi(x) = \frac{1}{\sqrt{l}} \cos \frac{\pi x}{2l}$$

The box width is $2l$ and the particle is confined within $(-l, +l)$. Calculate the expectation value of x^2. 8

(b) A particle is bound in a potential well given by

$$V(x) = \begin{cases} \infty & \text{for} \quad x \le 0 \\ cx & \text{for} \quad x > 0 \end{cases}$$

Estimate the ground state energy of the system from uncertainty principle. 8

(c) *(i)* Enumerate the possible values of quantum numbers j and m_j for state in which $l = 2$ and $s = 1/2$.

(ii) Draw the corresponding vector model diagram. 8

(d) Explain the concept of shared pair of electrons with antiparallel spins forming a covalent bond in H_2-like molecule with reference to total energy. 8

(e) A substance shows a Raman line at 4567 Å when exciting line 4358 Å is used. Estimate the positions of Stokes and anti-Stokes lines for the same substance when exciting line 4047 Å is used. 8

2. *(a)* Write down Schrödinger equations for a particle of energy $E < V_0$, incident on a step potential height V_0.

Solve them to find out the transmission and reflection coefficients in terms of k and k', where $k = \sqrt{\frac{2mE}{\hbar^2}}$ and $k' = \sqrt{\frac{2m(V_0 - E)}{\hbar^2}}$. Show that in this case, there is a finite probability of finding the particle in a classically forbidden region. 35

(b) Can you comment from the above question whether you can use it to scan surface by microscopy? 5

3. *(a)* Develop and write down the expressions of L^2, L_z and L_z^2 in angular momentum operator algebra. 10

(b) Show that the spherical harmonics $Y_{lm}(\theta, \phi)$ are simultaneous eigenfunctions of L^2, L_z and L_z^2. What are their corresponding eigenvalues? 30

4. *(a)* Discuss the vibrational spectra of a diatomic molecule treating potential energy function as a representation of Hooke's law type of interaction. 20

(b) Explain why the separation between vibrational levels is smaller in an excited electronic state than in the ground electronic state. 20

SECTION—B

5. *(a)* The masses of hydrogen atom and neutron are 1·007825 u and 1·008665 u respectively. Calculate the binding energy per nucleon of $^{12}_{6}C$ nucleus. 8

(b) How many fissions take place per second in a 300 MW reactor? Assume that 200 MeV is the energy released per fission. 8

(c) Write down the quark structure of π^0, π^+, K^0 and K^+ mesons. 8

(d) Write down London second equation for superconductors. Explain how it accounts for the Meissner effect. 8

(e) Prove the following Boolean identity and draw its gates equivalent : 8

$$Y = \overline{B}(A + C) + C(\overline{A} + B) + AC$$

6. *(a)* What is the importance of the study of deuteron? Discuss the problem of ground state of deuteron and elicit information about nuclear forces from this study. 20

(b) How magnetic moment and electric quadrupole moment of deuteron indicate the presence of non-central forces in deuteron? 20

7. *(a)* Why was neutrino invoked upon by Fermi and how was it placed into experimental evidence? 20

(b) What is solar neutrino problem and how the phenomenon of neutrino oscillations provides a solution for the problem? 20

8. *(a)* What is a thermistor? Discuss static characteristics of a thermistor. What is its time constant? 20

(b) In an operational amplifier, the amplifier gain is 10000. The input series resistance is 100 kΩ and the feedback resistance is 500 kΩ. If the input voltage is 1 volt, find the exact output voltage and percentage error considering an infinite gain for the amplifier. 20

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