C-HENT-N-YPNMB

PHYSICS
Paper – II

*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.*

*Questions no. **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} (A m^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 $\qquad$ $m(^4_2He) = 4{\cdot}002603$ u

$m(^{12}_6C) = 12{\cdot}00000$ u $\qquad$ $m(^{87}_{38}Sr) = 86{\cdot}908893$ u

$m(^2_1H) = 2{\cdot}014022$ u $\qquad$ $m(^3_1H) = 3{\cdot}0160500$ u

SECTION A

Q1. Answer all of the following : *8×5=40*

(a) What is the de Broglie wavelength of an electron whose kinetic energy is 100 eV ? *8*

(b) Normalize the ground state wave function

$$\psi_0(x) = A\, e^{(-\alpha x^2/2)}$$

for the simple harmonic oscillator and find expectation values $< x >$ and $< x^2 >$. *8*

(c) An atom in an excited state of 4·7 eV emits a photon and ends up in the ground state. The lifetime of the excited state is 10^{-13} s. Calculate the energy uncertainty and obtain the spectral line width in wavelength of photon. *8*

(d) What is Lamb shift ? How is it measured ? *8*

(e) Given that the rotational inertia of HCl molecule has the value $I = 2{\cdot}66 \times 10^{-47}$ kg-m^2, estimate the energy difference between the lowest and first excited state of HCl. *8*

Q2. (a) Derive an expression for transmission coefficient for a particle through a rectangular potential barrier. *20*

(b) Using WKB approximation find out the lifetime of α-emitter. *20*

Q3. (a) Show that

(i) no two of the three components of angular momentum operator commute and *10*

(ii) the third component of the angular momentum operator commutes with the square of angular momentum operator. *10*

(b) Discuss the different coupling schemes in atomic spectroscopy with suitable diagrams. *10*

(c) Explain the origin of the anomalous Zeeman effect. *10*

Q4. (a) Explain spin-spin and spin-lattice relaxation times in NMR spectroscopy. How do they influence the line width of the NMR line ? *10*

(b) How is proton magnetic resonance applied to determine the chemical shifts in molecules containing hydrogen atom ? Illustrate your answer with a suitable example. *10*

(c) What are the characteristics of a Raman spectrum ? How do you study Raman spectra in the laboratory ? Give two applications of Raman effect. *20*

SECTION B

Q5. Answer all of the following : *8×5=40*

(a) $^{27}_{14}Si$ and $^{27}_{13}Al$ are mirror nuclei. Their ground states are identical except the charge. If their mass difference is 6 MeV, estimate their radius neglecting the proton-neutron mass difference. *8*

(b) Calculate the energy released per gram of fuel for the nuclear reaction *8*

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}H$$

(c) Explain why each of the following reactions is forbidden : *8*

(i) $p + p \rightarrow p + p + n$

(ii) $p + p \rightarrow p + \pi^{+} + \gamma$

(iii) $\square^{0} \rightarrow n + \pi^{0}$

(iv) $\Lambda \rightarrow p + \pi^{0}$

(v) $\nu_e + p \rightarrow n + e^{+}$

(d) X-ray of wavelength 1·4 Å is found to be Bragg reflected from (111) plane of an fcc structure. If the lattice parameter of the crystal is 5 Å, find the angle at which the X-ray beam is incident on the (111) plane of the crystal. *8*

(e) A silicon diode operates at a forward bias voltage of 0·4 V. Calculate the factor by which the current will be multiplied when the temperature is increased from 25°C to 150°C (η for Si = 2). *8*

Q6. (a) How does the semi-empirical mass formula explain the stability of a nucleus against beta decay ? *20*

(b) Briefly explain the meson theory of nuclear force. *10*

(c) What are the major components of a fission reactor ? With a schematic diagram explain its working. *10*

Q7. (a) Explain in detail the classification of elementary particles. *20*

(b) What is ac Josephson effect ? Derive an expression for the current flowing through the junction formed by two superconducting films separated by an insulator. *20*

Q8. (a) Explain with the help of a neat diagram the structure of a n-channel FET and its IV characteristics. In what way is an FET different from a BJT ? *20*

(b) Show that the NAND gate is a universal gate. *10*

(c) For the logical equation given below, form the truth table and draw the corresponding logic circuit using different gates : *10*

$$Y = A \cdot B + \overline{A \cdot B}$$