I.F.S. EXAM-2015

C-GEQ-O-QIZB

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 sequential 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} ($N\ m^2$)
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 questions : *8×5=40*

(a) Give an account of Heisenberg's Uncertainty principle. Outline an idealised experiment to bring out its significance. *4+4=8*

(b) Find the de Broglie wavelength of a neutron moving with a kinetic energy of 500 eV. *8*

$(1\ eV = 1{\cdot}602 \times 10^{-19}\ J)$

(c) Determine the values of the total angular momentum for a 3d electron. *8*

(d) Use Hund's rules to find the ground-state quantum numbers, L and S of (i) Carbon and (ii) Oxygen atoms. *4+4=8*

(e) Calculate the strength of the magnetic field to bring a proton nucleus and a ^{13}C nucleus to resonate at this frequency. Magnetic moment of proton = $2{\cdot}7927\ \mu_N$ and magnetic moment of $^{13}C = 0{\cdot}7022\ \mu_N$. The NMR instrument operates at 30·256 MHz. *8*

Q2. (a) Deduce the commutation relations between the components of angular momentum operator L

$$[L_x, L_y] = i\hbar\ L_z$$

$$[L_y, L_z] = i\hbar\ L_x$$

$$[L_z, L_x] = i\hbar\ L_y$$

using the commutation relations

$$[x, p_x] = [y, p_y] = [z, p_z] = i\hbar$$ *20*

(b) Solve the Schrödinger equation for an electron of mass m confined in a one-dimensional potential well of the form

$V = 0$, when $0 \le x \le L$

$= \infty$, when $x < 0;\ x > L$

Obtain the discrete energy levels and the normalized eigen functions. *10+5+5=20*

Q3. (a) State the postulates of Bohr regarding his atom model. Obtain the expressions for the radius and electron-energy of the n^{th} orbit. Explain how Bohr's atom model successfully accounts for the hydrogen spectrum. *5+10+5=20*

(b) Explain Russel Saunders coupling. Discuss the summation rules for orbital angular momentum, spin angular momentum and total angular momentum quantum numbers. *5+5=10*

(c) What is 'multiplicity' ? Give the term symbol for the following cases : *2+4+4=10*

(i) $S = \frac{1}{2}$ $L = 2$

(ii) $S = 1$ $L = 1$

Q4. (a) Distinguish between fluorescence and phosphorescence in electronically excited molecules. *10*

(b) Calculate the most probable value of 'r' for an electron in the ground state of the hydrogen atom. *10*

(c) Derive the rotational-vibrational energy levels of a diatomic molecule. Give the analysis of spectral lines. *15+5=20*

SECTION B

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

(a) Discuss the four basic types of fundamental interactions in nature and compare them. *4+4=8*

(b) What is kinematics of nuclear reaction ? What is the Q-value and its significance ? *4+4=8*

(c) Compute the density of a typical nucleus and find the resultant mass, if we could manufacture a nucleus with a radius of 1 cm. *8*

(d) What are called intrinsic and extrinsic semiconductors ? *4+4=8*

(e) Construct the following function with logic gates : *4+4=8*

$$Y = (A + B)(C + D + E)(F + G + H + I)(JKL)$$

Q6. (a) Explain the term critical magnetic field in a superconductor. How does the critical magnetic field vary with temperature in Type-I and Type-II superconductors ? What is Meissner effect ? *5+10+5=20*

(b) Discuss the shell model of the nucleus. What are its merits ? *15+5=20*

Q7. (a) With a suitable circuit diagram and theory explain the use of OP-Amps as

(i) Adder, and

(ii) Integrator. *10+10=20*

(b) Describe the quark model. Obtain the quark composition of baryons and mesons. *10+5+5=20*

Q8. (a) Obtain the ground-state wave function, depth of potential and range of nuclear force in deuteron and discuss. Also prove that no bound state exists for $l \neq 0$. *5+5+5+5=20*

(b) Explain the operation of NOR gate with a logical diagram and truth table. Show how NOR gate can be used as Universal gate. *5+5+10=20*