वियोज्य DETACHABLE

I.F.S. EXAM-(M)2017

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.

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 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	=	$1{\cdot}673\times10^{-27}$ kg
Mass of neutron	=	$1{\cdot}675\times10^{-27}$ kg
Mass of electron	=	$9{\cdot}11\times10^{-31}$ kg
Planck constant	=	$6{\cdot}626\times10^{-34}$ Js
Boltzmann constant	=	$1{\cdot}380\times10^{-23}$ JK^{-1}
Bohr magneton (μ_B)	=	$9{\cdot}273\times10^{-24}$ A m^2
Nuclear magneton (μ_N)	=	$5{\cdot}051\times10^{-27}$ JT^{-1} (A m^2)
Electronic charge	=	$1{\cdot}602\times10^{-19}$ C
Atomic mass unit (u)	=	$1{\cdot}660\times10^{-27}$ kg
	=	931 MeV

$g_s^p = 5{\cdot}5855\ \mu_N$

$m(n) = 1{\cdot}00866$ u

$m(^{12}_{6}C) = 12{\cdot}00000$ u

$m(^{2}_{1}H) = 2{\cdot}014022$ u

$m(^{16}_{8}O) = 15{\cdot}999$ u

$\hbar = 1{\cdot}05\times10^{-34}$ Js

$\hbar c = 197$ eVnm

$m(p) = 1{\cdot}00727$ u

$m(^{4}_{2}He) = 4{\cdot}002603$ u

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

$m(^{3}_{1}H) = 3{\cdot}0160500$ u

SECTION 'A'

1. Answer all of the following questions : $8 \times 5 = 40$

1.(a) Use the uncertainty principle to estimate the binding energy of the hydrogen atom in the ground state in terms of m_e, e, $\hbar$ and c. Estimate the answer in eV. 8

1.(b) An electron is described by the following wave function :

$$\psi(x) = 0 \quad \text{for } x < 0$$
$$= Ce^{-x}(1 - e^{-x}) \text{ for } x \geq 0$$

where C is a constant. Find out the average position of the electron. 8

1.(c) What is the main inference drawn from the Stern Gerlach experiment ? What would be the change in the result in the following cases :

(i) electron spin is $\frac{3}{2}\hbar$ instead of $\frac{\hbar}{2}$.

(ii) a beam of neutral atoms is passed through a homogeneous magnetic field. 8

1.(d) What is meant by Larmour precession ? Calculate the Larmour frequency for protons in a magnetic field of 1 Tesla. 8

1.(e) Describe the differences in the behaviour of a quantum harmonic oscillator with the corresponding classical oscillator. 8

2.(a) A particle of mass m is confined in a one dimensional box on the x-axis between $x = 0$ and $x = L$. Obtain the allowed energy states of the particle and the corresponding eigenfunctions. What will be the energy pattern in the limit of $L \to \infty$? 15

2.(b) Estimate the probability of finding the particle between $x = 0$ and $x = \frac{L}{3}$ in the lowest energy state. 5

2.(c) Generalize the results obtained in part (a) to obtain the allowed energy states and the corresponding eigenfunctions of a particle in a three dimensional isotropic box of dimension L. What is the degeneracy of the first two excited states of the particle ? 20

3.(a) Consider two electrons system in $(3p)'(4s)'$ configuration. Derive the allowed energy states of the system in (i) LS coupling and (ii) jj coupling sketching the energy level diagram in each case. Name the interactions which are responsible for different splittings. 25

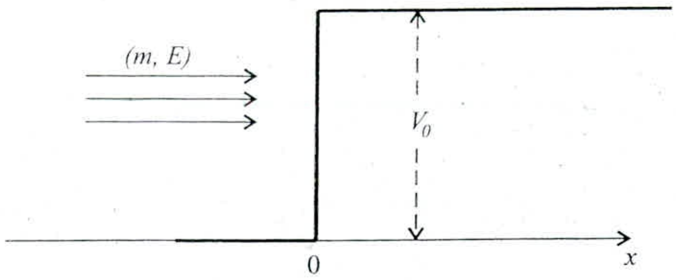
3.(b) Show that

(i) $\hat{L} \times \hat{L} = i\hbar\hat{L}$

(ii) $\left[\hat{L}_+, \hat{L}_-\right] = 2\hbar\hat{L}_z$

(iii) $\hat{\sigma}_x \hat{\sigma}_y \hat{\sigma}_z = -i$ 15

4. (a)



A beam of particles of mass m and energy E is incident on a step potential of height V_0 from the left as shown in the figure. Discuss the behaviour of the particle for (i) $E < V_0$ and (ii) $E > V_0$. Obtain expressions for the reflection and the transmission coefficients and sketch them as a function of the incident energy of the particle. 15

4. (b) The first rotational line in the rotational spectrum of CO is observed at $3{\cdot}84235\ \text{cm}^{-1}$. Calculate the rotational constant B and the bond length. 10

4. (c) What are Stokes and anti-Stokes lines ? What is their importance in understanding the molecular structure ? 15

SECTION 'B'

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

5. (a) How much energy is required to separate $^{16}_{8}O$ nucleus into its constituent nucleons ? What is the binding energy per nucleon for this nucleus ? 8

5. (b) Determine the values of emitter current and the collector current of the transistor having $\alpha = 0{\cdot}98$ and collector to base leakage current $I_{CBO} = 4\ \mu A$. The base current is 50 μA. 8

5. (c) What are noncentral nuclear forces ? Discuss qualitatively how the presence of a small noncentral component in the nuclear force can account for the nonvanishing quadrupole moment of deuteron. 8

5. (d) Define the terms critical magnetic field and critical temperature in a superconductor. Find the magnetic field strength necessary to destroy the superconductivity in a sample of lead at 4·2 K. The critical magnetic field at 0 K is 0·80 Tesla and the critical temperature is 7·2 K. 8

5. (e) Write the quark contents and the quantum numbers (B, J, s, I_3) of the following hadrons :

$\bar{\Sigma}, \Xi^{\circ}, \Pi^{+}, \bar{K}^{\circ}$ 8

6. (a) What is meant by quark confinement ? Why are the masses of hadrons larger than the sum of the masses of their constituent quarks ? 12

6. (b) Describe the main features of the shell model of the nucleus. Explain how it can account for the magic numbers of nuclei. 20

6. (c) Predict the spin and parity for the ground state of the following nuclei on the basis of the shell model :

$^{15}_{8}O$, $^{16}_{8}O$, $^{17}_{8}O$, $^{18}_{8}O$ 8

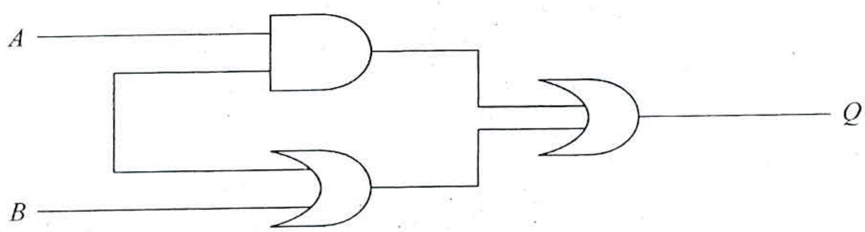
7. (a) Write down the semiempirical mass formula for nuclei and sketch the variation of isobaric masses with atomic number for both odd and even values of A. How many stable isobars would be there in each case ? 20

7. (b) What is Meissner effect ? Explain perfect diamagnetism in reference to this. 10

7. (c) Explain briefly SU(3) flavor symmetry and SU(2) isospin symmetry in particle physics. 10

8. (a) Explain with the help of a neat diagram the working of an RC coupled common emitter amplifier. 15

8. (b)



Find the Boolean algebra expression for the above system. 15

8. (c) Why does the resistance of a semiconductor decrease with increase in temperature ? 10