भारतीय वन सेवा परीक्षा 2011
Indian Forest Services Examination

Sl. No. 7841

D-VSF-L-CUB

PHYSICS

Paper II

Time Allowed : Three Hours | *Maximum Marks : 200*

INSTRUCTIONS

Candidates should attempt questions ***1*** *and* ***5*** *which are compulsory, and any* ***THREE*** *of the remaining questions, selecting at least* ***ONE*** *question from each Section.*

All questions carry equal marks.

Marks allotted to parts of a question are indicated against each.

Answers must be written in ***ENGLISH*** *only.*

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

Neat sketches may be drawn, wherever required.

(Contd.)

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	$= 9{\cdot}273\times10^{-24}$ A/m^2
Nuclear magneton (μ_N)	$= 5{\cdot}051\times10^{-27}$ $JT^{-1}(Nm^2)$
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(p)	$= 1{\cdot}00727$ (u)
m(n)	$= 1{\cdot}00866$ (u)
$m\left({}_{2}^{4}He\right)$	$= 4{\cdot}002603$ u
$m\left({}_{6}^{12}C\right)$	$= 12{\cdot}00000$ u
$m\left({}_{38}^{87}Sr\right)$	$= 86{\cdot}908893$ u

Section 'A'

1. Answer any *four* of the following :

(a) On the basis of uncertainty principle calculate the size of Hydrogen atom. 10

(b) What are Pauli spin matrices ?

Show that :

$$\left(\vec{\sigma}\cdot\vec{A}\right)\left(\vec{\sigma}\cdot\vec{B}\right)=\vec{A}\cdot\vec{B}+i\vec{\sigma}\cdot\left(\vec{A}\times\vec{B}\right)$$

where $\vec{\sigma}$ are the Pauli spin matrices and $\vec{A}$ and $\vec{B}$ are vector operators which commute with $\vec{\sigma}$, but do not necessarily commute with each other. 10

(c) Obtain the term symbols for two singlet states and two triplet states for two electron atoms. 10

(d) The wavelengths (λ) in the visible spectrum of H atom can be expressed by the empirical formula

$$\lambda=\left(\frac{n_1^2}{n_1^2-4}\right).G$$

where n_1 is an integer and n_1 = 3, 4 etc. and G is an empirical constant.

Prove from the above, the wave number

$$\bar{\nu}=R_H\left(\frac{1}{2^2}-\frac{1}{n_1^2}\right),\ \text{where}\ R_H=\frac{4}{G}. \qquad 10$$

(e) What is the mechanism of emission of light in fluorescent lamps and in painted signboards ? Explain. 10

2. (a) For a quantum mechanical system prove that all energy eigen-values E_n are real and if $E_n \neq E_k$, then the corresponding eigen functions are orthogonal. 10

(b) Solve the Schrodinger equation for a potential step function given by

$$v(x) = 0 \text{ for } x < 0$$
$$= v_0 \text{ for } x > 0$$

and calculate the reflection and transmission coefficients. Show that for $E < v_0$ there is a finite probability of finding the particle in a classically forbidden region. 20+10

3. (a) Solve the eigen value equation

$L^2 Y(\theta, \phi) = \lambda \hbar^2 Y(\theta, \phi)$ and obtain the eigen values and eigen functions of L^2. 20

(b) (i) What angles do the $\vec{L}$(vector) make with the z-axis when $l = 2$ for an electron ?

(ii) Determine the values of the total angular momentum for a $3d$ electron. 20

4. (a) Discuss the vibrational spectra of a diatomic molecule treating it as an anharmonic oscillator. 20

(b) Give the elementary theory of NMR. Explain the two different relaxation processes. 20

Section 'B'

5. Answer any *four* of the following :

(a) Find the density of ${}^{12}_{6}C$ nucleus. (Given, nuclear radius of carbon = $2{\cdot}7\times10^{-15}$ m) 10

(b) Explain the source of energy in stars using proton-proton thermonuclear reaction cycles. 10

(c) What type of interaction takes place in the following reactions and justify your answer.

(i) $\mu^- \longrightarrow e^- + \nu_e + \bar{\nu_\mu}$

(ii) $p + \mu^- \longrightarrow n + \nu_\mu$ 10

(d) How are the band structures of insulators and semiconductors, similar ? How are they different ? 10

(e) (i) What are intrinsic and extrinsic semiconductors ? Explain.

(ii) How are *n*-type and *p*-type semiconductors obtained ? 10

6. (a) What are magic numbers in an atomic nucleus and why are they so called ? How is it explained using nuclear shell model ? 20

(b) What are the reactor materials used in design and construction of a nuclear reactor and their important functions ? 20

7. (a) What are quarks ? Give any four properties. Give quark composition of the following particles :

p, n, Λ°, Π^{+}, K^{+} 20

(b) Using band theory of solids, explain whether the effective mass of an electron can be positive, negative as well as infinity. Explain the significance of negative mass. 20

8. (a) Using OP-AMPs design an analog circuit to solve the following differential equation :

$$\frac{d^2v}{dt^2} + k_1\frac{dv}{dt} + k_2 v = v_1(t)$$

with $\frac{dv_{(0)}}{dt} = 1{\cdot}5$ V; $v_{(0)} = 2{\cdot}0$ V. 20

(b) Explain the basic structure and operation of an *n*-channel FET.

How FET acts as an amplifier ? Explain. 20