2016

BW-(O)PS-II/16

PHYSICS -II

Time Allowed : 3 Hours

Full Marks : 200

If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.

Answers may be written either in English or in Bengali but all answers must be in one and the same language.

Group A

Answer any six questions

1. (a) After suitable normalization obtain the probability density and the probability current density for a particle of mass m whose wave function is given by

$$\psi(x) = e^{-x^2/2+ip_0x/\hbar}$$

(b) The uncertainty in the mass measurement of an elementary particle is 1 MeV. Estimate its lifetime.

6+4

2. (a) Write down the Hamiltonian for the hydrogen atom. Sketch the wave function for the ground state.

(b) Two particles have angular momenta $3/2\hbar$ and $5/2\hbar$, respectively. What are the possible total angular momenta values for the two particle system?

Write down the spectroscopic notation for the ground state of Na(Z=11) atom.

What is Hund's rule? Write down the electronic configuration of oxygen atom(Z=8) using Hund's rule.

(2+2)+(2+2+2)

3. (a) Describe the working principle of a Bainbridge mass spectrograph. The deflecting magnetic field of a Bainbridge mass spectrograph is 0.08 Tesla. What is the separation between the traces produced by singly ionized ^{20}Ne and ^{22}Ne when all the atoms have the same initial velocity of 10^5 m/sec.

(b) A $^7_3$Li nucleus is bombarded with protons and α-particles are emitted in the reaction. Calculate the kinetic energy of the α-particle assuming the kinetic energy of the bombarding proton to be negligible. [Given M($^7_3$Li) = 7.016004 a.m.u, M(p)=1.007826 a.m.u. and M(α)=4.002603 a.m.u.]

(5+2)+3

P.T.O.

4. (a) Draw the energy spectrum of the β-particle in β-decay. Explain the origin of its continuous nature.

   (b) Indicate the fundamental interaction through which the following processes occur.

   (i) $n \longrightarrow p + e^- + \bar{\nu}$

   (ii) $p + p \longrightarrow p + p + p + \bar{p}$

   (iii) $\gamma \longrightarrow e^+ + e^-$

(3+4)+3

5. (a) Determine the phase trajectory of a one dimensional linear harmonic oscillator of constant energy E moving along the x-axis.

   (b) Derive the Bose-Einstein distribution formula stating the assumptions clearly.

3+7

6. (a) Show that at $T = 0$, the average energy of an electron in a metal is $3\epsilon_F/5$, where ϵ_F is the Fermi energy.

   (b) The radiation from a black body at temperature 2900 K peaks at 1000 nm. If the solar radiation peaks at 500 nm, find out the temperature of the surface of the Sun.

8+2

7. (a) Distinguish between crystalline and amorphous materials.

   (b) Find out the packing fraction for BCC and FCC crystals.

   (c) What is Meissner effect in superconductivity?

4+4+2

8. (a) What is feedback? What is the importance of negative feedback?

   (b) Draw the circuit of a Weinbridge oscillator and explain its working.

2+2+6

Contd..P/3..

9. (a) Draw the circuit of an integrator using OP-AMP and explain its working.

(b) Draw a neatly labelled diagram of a FET. What are the advantages of a FET over a transistor?

5+2+3

Group B

Answer any seven questions

10. (a) A particle is enclosed in a one-dimensional box with rigid walls. Solve the Schroedinger equation for the system and obtain the energy values and wave-functions.

(b) The following data are from a Stern Gerlach experiment with silver ($Z = 47, A = 108$):

Initial speed of the silver atoms - 10^3m/sec

Length of the magnetic field zone - 0.03m

Rate of variation of flux density - 1.6T/mm

Distance of screen from mid-point of magnetic field - 0.10 m

If the magnetic moment along the magnetic field is given by 9×10^{-24}J/T. obtain the maximum separation between the two traces. Deduce any formula you use.

10+10

11. (a) Sketch a one-dimensional harmonic oscillator potential. Write down the energy eigenvalues. Sketch the wave function for the first three states.

Consider a two dimensional symmetric harmonic oscillator with frequency ω. Find out the degeneracy of the state with energy $5\hbar\omega$.

(b) Describe the feature of anomalous Zeeman effect that could not be explained classical theory.

(c) What are Stokes and anti-Stokes lines?

(2+2+4+4)+5+3

12. (a) Write down the semi-empirical mass formula and explain its different terms. Explain from the mass formula why odd-odd nuclei are rare in nature.

    (b) What are the evidences in favour of the nuclear shell model? Explain the importance of the spin-orbit interaction in the shell model.

(3+6+2)+(6+3)

13. (a) Describe Wu's experiment and show how it established non-conservation of parity in weak interaction.

    (b) Describe the ppI chain for production of energy in stars.

    (c) Draw the $I_3 - Y$ plot of the octet of pseudoscalar mesons indicating the respective particles.

10+6+4

14. (a) Using Debye's theory, find out an expression for specific heat of solids. explain how it differs from classical theory.

    (b) The partition function of a system is given by $z = \sum g_j e^{-E_j/k_B T}$ where the symbols have their usual meanings. Find out an expression for the number of particles in the i-th state.

    (c) Three identical particles can be distributed in three single particle states. Find out the number of possible states if the particles obey (i) Bose-Einstein;(ii) Fermi-Dirac and (iii) Maxwell-Boltzmann statistics.

(7+3)+(4+6)

15. (a) Obtain the Maxwellian velocity distribution formula for an ideal gas.

    (b) Define C_P and C_V. Explain how they change with temperature for a diatomic gas.

10+(4+6)

16. (a) Describe the powder method of X-ray diffraction.

(b) In a Davisson-Germer setup, Ni crystals are used for electron diffraction. If a peak is obtained at 50^o for lattice spacing $D =$ 0.215nm, find the kinetic energy of the electron.

(c) Distinguish between ferromagnetism, diamagnetism and paramagnetism.

8+6+6

17. (a) Discuss the band structure of metals, conductors and semiconductors.

(b) For two crystals NaCl and KCl, we have the ratios

$$\frac{(d_{100})_{NaCl}}{(d_{100})_{KCl}} = \frac{(d_{110})_{NaCl}}{(d_{110})_{KCl}}$$

when the symbols have their usual meaning. However, the ratio for the (111) planes has twice the value. How can this be explained?

(c) Obtain an expression for Hall Voltage in a intrinsic semiconductor sample.

8+6+6

18. (a) Prove the following Boolean identities:

(i) $\overline{AB + BC + CA} = \bar{A}\bar{B} + \bar{B}C + \bar{C}A$

(ii) $A(A + \bar{B}C) + A(\bar{B} + C) = A$

(iii) $(A + \bar{B})(\bar{A} + C) = AC + \bar{A}B$

(b) Design a logic circuit to implement the following:

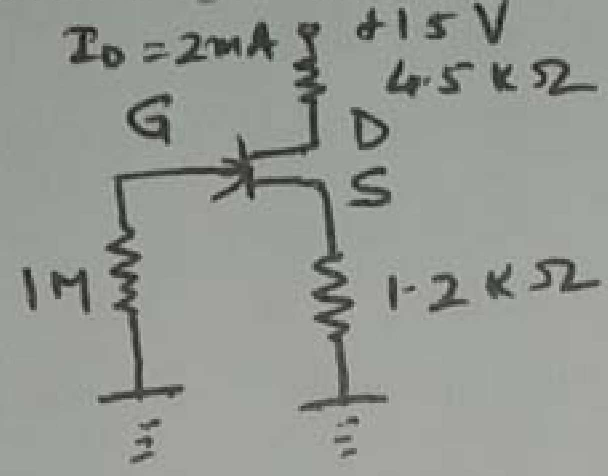
$$Y = ABC + A\bar{B} + \bar{A}C + \bar{C}$$

(c) Sketch the circuit for a NOR gate Using diodes and transistors and explain its working.

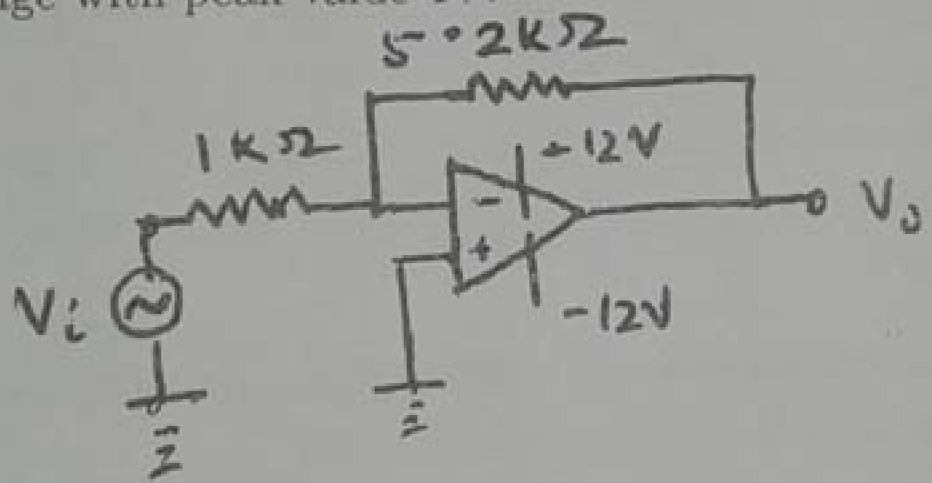
(4+4+4)+3+5

19. (a) Draw the transfer characteristics of a transistor in the CE mode. Indicate the different regions.

(b) Find the drain-to-source voltage and the gate-to-source voltage for the following circuit.



(c) Plot the output for the following circuit, if the input is a sinusoidal voltage with peak value 4V.



(6+2)+8+4