2016

PHYSICS

[Honours]

PAPER – VI

Full Marks : 90

Time : 4 hours

The figures in the right hand margin indicate marks

GROUP – A

Answer any **two** questions :   15 × 2

1. (a) What is a schmitt trigger ? Draw schematically an OPAMP schmitt trigger and explain its operation. Sketch the transfer characteristics and indicate the hysteresis. 1 + (1 + 2) + 2 + 1

   (b) What is a multiplexer ? How can you design a 4 to 1 multiplexer using basic gates ?   4

   (c) Design a logic circuit (Block diagram) for adding two decimal numbers 5 and 7. Write down the result in binary.   4

2. (a) The mid-band gain of a RC-Coupled amplifier is 150. It is found the values of the gain of the amplifier are 50 at frequency 40 Hz and 60 at frequency 500 kHz. Find the bandwith of the amplifier.

3

(b) What is the time-base generator in a CRO ? Explain its function. Explain briefly how a waveform is displayed on the screen of a CRO.

(2 + 2) + 3

(c) Write the characteristics of a 8085 μp. Write the meaning of the following instructions regarding 8085-μp : LDA E050$_H$, STA E100$_H$, CMP B, INX H;

2 + 3

3. (a) Give an outline of Davisson-Germer experiment and the conclusion drawn from it.

5

(b) In a Davisson-Germer diffraction experiment electrons of K.E. 100 eV are scattered from a crystal. The first maximum in intensity

(*Continued*)

occurs at $\theta = 10^0$. What *is* the spacing between the crystal planes ? How many peaks will be there in the interference pattern ?

$$[\sin 10^{\circ} = 0.174]$$ 2 + 2

(c) Give an interpretation of the wave function associated with a particle.   3

(d) The life time of a nucleus in an excited state is 10^{-12}S. Calculate the probable uncertainty in the energy and frequency of a γ-ray photon emitted by it.   3

4. (a) What is a wave packet ? Explain how a wave packet may be formed by the superposition of two or more monocromatic waves of slightly different wavelengths. Define phase velocity and group velocity.   1 + 3 + 2

(b) Prove that the velocity of the particle is equal to the group velocity of the corresponding wave packet. (Consider only nonrelativistic case).   2

(Turn Over)

(c) What are stationary states ? Prove that a super position state (component states having different energies) does not represent a stationary state.

$1 + 2$

(d) A particle of mass m is confined to move in a potential $V(x) = 0$ for $0 \leq x \leq a$
$$= \alpha \text{ otherwise}$$

The wave function of the particle at time $t = 0$ is given by $\psi(x) = A \sin \frac{2\pi x}{a} \cos \pi x / a$

(i) Normalise $\psi(x)$

(ii) Find the average value of the energy of the particle.

$2 + 2$

GROUP – B

Answer any **five** questions :

8×5

5. (a) Show that commutating operators have common set of eigen functions.

2

(b) The operator $\left(x + \dfrac{d}{dx} \right)$ has the eigen value α. Derive the corresponding eigenfunction.

2

(c) Explain the non-existance of electrons inside the nucleus using uncertainty principle. 4

6. (a) Show that Bragg's law in the reciprocal space can be expressed as $2\vec{K} \cdot \vec{G} + G^2 = 0$ where $\vec{K}$ is the wave vector and $\vec{G}$ is the reciprocal lattice vector. 4

(b) What are Brillouin Zones ? Obtain and construct 1st Brillouin Zones for a square lattice. 4

7. (a) What is dipolar polarisability ? Obtain an expression for dipolar polarisability of a dielectric at moderate temperature and the field strength is not too high. 4

(b) The emergy of a system of two atoms in the field of each other is given by

$$U(r) = -\frac{\alpha}{r} + \frac{\beta}{r^8},$$

where α and β are constants and r is the distnance between the centres of the atoms.

Show that (i) two atoms form a stable compound for $r = r_0 = (8\beta/\alpha)^{1/7}$ (ii) Show that if the atoms are pulled apart the molecule will brake as soon as $r_c = \left(\dfrac{36\beta}{\alpha}\right)^{1/7}$ and find the minimum force.

2 + 2

8. (a) Derive an expression for deflection sensitivity of a CRT using electrostatic deflection.

4

(b) What do you mean by the term 'Modulo-N Counter ? Design a Mod-10 ripple counter and explain its operation with the help of truth table and waveforms.

4

9. (a) What is Race-around Condition in JK FF ? How it is eliminated in JK/MS FF ?

2 + 2

(b) What is a shift-register ? Explain the operation of a 4-bit shift-register.

1 + 3

0. (a) Discuss the Curie-Weiss theory of spontaneous magnetization of ferromagnetic material.

5

(b) The Curie temperature of iron is 1043 K and each iron atom has a magnetic moment $2 \mu_B$, where μ_B = Bohr Magneton. If the saturation magnetizaton of iron is $1 \cdot 75 \times 10^6$ A/m, calculate Weiss-Constant and the Curie-temperature.　　3

11. (a) Consider a particle in a potential which is independent of time. Assuming that its wavefunction can be written as

$$\Psi(\vec{r}, t) = \Psi(\vec{r}) f(t),$$

obtain the equations satisfied by $\Psi(\vec{r})$ and $f(t)$, which of these equations is called the time-independent Schrödinger equation ? 4 + 1

(b) Show that the eigenfunctions corresponding to distinct eigenvalues of Hamiltonian are orthogonal.

12. (a) A wien bridge oscillator is to span a range of frequencies from 300 Hz to 30 kHz. The variable capacitance can be changed from 50 pF to 500 pF. Find the resistance needed

to span the frequency range. If the gain of the amplifier is 6, what must be the ratio of the resistances in other arms of the bridge ?   4

(b) Show how an S-R flip flop can be converted into J-K flip flop.   2

(c) How many data lines are required in the context of 8085 processor ? What is the largest number appearing on its data bus ?   2

GROUP – C

Answer any **five** questions :   4 × 5

13. Write the assembly language program for a 8085 processor to perform the following operations :

(i)   Load 76 H in the accumulator
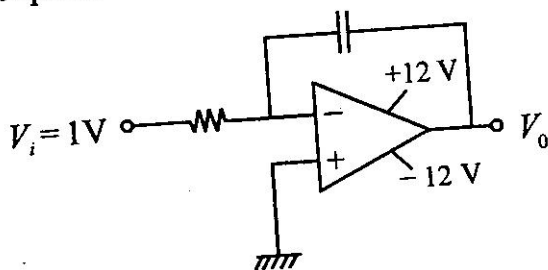
(ii) Load B5 H in the register E

(iii) Add these two numbers.

Which will be the content in the accumulator ? Also show the status of the flags CY, S and Z.
    2 + 1 + 1

14. Draw the actual output of the following integrator circuit when 1V dc is applied in its input. Calculate the ouput after 10 sec.   4

15. Draw the logic diagram of a decade counter and describe its operation.   4

16. Silver (fcc) has an atomic radius of 1.4 Å. Assuming silver to be monovalent metal, calculate the value of Fermi energy, Fermi temperature and the Fermi velocity.

[Given $\hbar = 1.05 \times 10^{-34}$ J-S, $m = 9.1 \times 10^{-31}$ kg, $K_B = 1.38 \times 10^{-23}$ J/K]

17. (a) Wavelength can be determined with an accuracy of 10^{-8} m. What is the

uncertainty in the position of a 10 Å photon when its wavelength is simultaneously measured.

2

(b) The time independent wavefunction of a system is $\psi(x) = A \exp(ikx)$, where k is a constant. Calculate the probability current density.

2

18. The raising (L_+) and lowering (L_-) operators for orbital angular momentum states change the value of m by one unit. Where $m\hbar$ is the eigenvalue of the operator L_z. Then show that

(i) $L_- L_+ = L^2 - L_z^2 - \hbar L_z$

(ii) $L_+ f_l^m = \hbar \sqrt{l(l+1) - m(m+1)} \; f_l^{m+1}$

where f_l^m is the normalised simultaneous eigen states for the operators L_z and L^2.

4

9. Define the term 'effective mass' of an electron in a lattice. Is it different from that the free electron ? What is the physical significance of the concept of effective mass.

4

20. Find the average distance of $1s$ electron from the nucleus if the wavefunction for $1s$ orbital of hydrogen atom is

$$\Psi(1,0,0) \frac{1}{\sqrt{\pi a_0^3}} e^{-r/a_0}$$

4

where a_0 = Bohr radius.

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