

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) State and explain Heisenberg's uncertainty principle. Why free electrons cannot stay in the atomic nuclei.

(b) Show by solving Schrodinger equation, that a free particle cannot have negative energy.

5+5

2. (a) Define probability current density and relate it to position probability density.

(b) If a system has two eigen states having two eigen values E_1 and E_2 , then show that the linear combination of those be an eigen state.

5+5

3. (a) Define chain reaction. What is a nuclear reactor? State its principle and explain the function of a moderator in nuclear reactor.

(b) Explain the difference of nuclear fission and fusion with examples.

5+5

4. (a) What is the origin of cosmic rays. Explain the hard and soft components of cosmic rays.

(b) Explain briefly the discovery of anti-proton. How is its mass ascertained in the experimental method?

5+5

5. (a) Determine the phase trajectory of one dimensional Linear Harmonic Oscillator, of constant energy E along X -axis.

(b) Starting from the MB velocity distribution system find the number of particles having Kinetic energy between E to $E+dE$

5+5

6. (a) Compare among MB, FD and BE distribution functions.

(b) Find out electronic specific heat of a metal behaves as a function of temperature.

5+5

7. (a) What is MOSFET? Why it is commercially more important than JFET. What is the main physical difference between them? What is threshold voltage of MOSFET?

(b) Draw the circuit diagram of a Differentiator using OPAMP and explain its working principle.

5+5

8. (a) What is the surprising action of transistor as stated by Shockley? Hence explain the current components of transistor.

(b) Draw a Self Bias circuit. Why it is called so? Define Bias curve and explain its significance.

5+5

9. (a) What is the difference between ferromagnetic and paramagnetic materials. How does magnetic domain be explained with reference to ferromagnetic materials.

(b) Derive Curies' law of Para magnetism from Langevin's theory.

5+5

Group B

(Answer any seven questions)

10. (a) Derive Planck's law of Radiation from Bose- Einstein's formula. Hence find the expression of Rayleigh-Jeans Law and Stefan's law.

(b) A system has two non-degenerate energy level $E_1=0$ and $E_2=0.1\text{eV}$. What is the temperature at which the probability of the system occupying the higher energy level is 0.25?

(5+5)+10

11. (a) Define Q value of a nuclear reaction. Derive an expression for Q-value of the reaction $X(a,b)Y$ in terms of kinetic energies of the incident and product particles and masses. Assume the target nucleus to be at rest at the laboratory.

(b) Define and explain the term nuclear reaction cross-section. What are its units? If a beam of N particles is incident on a slab of thickness x of a material, how many particles will come out of the slab? (Assume that the slab contains n atoms per unit volume and 'a' is the cross section of the reaction).

12. (a) Explain the terms mass defect, packing fraction, binding energy of a nucleus and BE per nucleon. Sketch and explain the variation of packing fraction with mass number.

(b) What are the magic number nuclei? How does the shell model explain the existence of magic numbers 2, 8, 20, 28 only. What is the significance of those magic numbers stated above?

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

13. (a) Find the probability current density for the lowest energy state of wave function of LHO. Comment on the graphical plot.

(b) Show by direct substitution that the eigen value and the eigen function corresponding to $n=1$ of simple LHO satisfy the time independent Schrodinger equation.

(8+2)+10

14. (a) Find the probability of transmission of alpha particle through a rectangular potential barrier.

(b) What is lasing action? Derive the Einstein's A&B coefficients related to laser radiation. Determine the ratio of stimulated emission to spontaneous emission for a laser of wavelength 634.8 nm at room temperature.

10+(2+5+3)

15. (a) Define positive and negative logic system. Draw the circuit of a NOR gate using NAND gate. What is tri-state logic? Explain the need for tri-stating.

(b) What are the advantages of negative feedback in amplifiers? Give a neat circuit diagram of Wien Bridge oscillator and explain its working principle. Find the expression for the frequency of oscillation.

(3+3+3+1)+(2+5+3)

16. (a) What is pinch-off voltage of FET? Derive the expression of the same. Calculate the drain current level of a FET when the gate voltage V_{gs} is equal to the one half of the pinch-off value. Assume $I_{dss} = 15\text{mA}$.

(b) i) Express the decimal number -71 in the 8-bit 2's complement form.

ii) Convert $(175)_{10}$ to octal form.

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

17. (a) Derive Fermi-Dirac statistics, stating its assumptions. Draw the distribution function curve as a function of temperature.

(b) i) What is Gibbs paradox? Why does it arise and how is it avoided?

ii) Six distinguishable particles are distributed over three non-degenerate levels of energies 0, E and 2E. Calculate the total number of micro-states of the system. Find the total energy of the distribution for which the probability is a maximum.

(8+2) + (4+6)

18. (a) i) Discuss the periodicity character of potential in a crystal. State and prove Bloch theorem in this reference.

ii) Prove that the motion of an electron through the periodic potential of solids gives rise to band structure.

(b) Discuss Kronig-Penney model of band theory of solids. Using the model, show that the energy spectrum of electron consists of a number of allowed energy bands separated by forbidden regions.

(5+5)+(5+5)

19. (a) Why are X-rays used for crystal structure analysis? Explain why a crystal diffracts X-rays. Derive Bragg's law of crystal diffraction and explain its physical significance.

(b) i) What is a reciprocal lattice? Why is it named so? Derive the expression for the primitive translation vectors of the reciprocal lattice.

ii) What is a phonon? Explain the vibrational modes of a diatomic linear lattice structure. Name the different branches of dispersion relation curve. What is the difference between the two branches?

(3+2+5)+(1+1+3)+(1+2+1+1)