CSM—55/23

PART—II/PAPER—VII

PHYSICS

PAPER—II

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Time : 3 Hours

Full Marks : 250

The question paper contains **18 (Eighteen)** *questions in* **GROUP—A (12)** *and* **GROUP—B (06)** *together.*

GROUP—A

Candidates to attempt **10** ***(ten)*** *questions within word limit of* **250**. *Each question carries* **15** *marks.*

1. A positron and an electron having negligible kinetic energies annihilate each other to produce two photons. Calculate the frequencies of the two photons.

2. What are the differences between AC and DC Josephson effects?

3. If the double splitting of the first excited state, $2\,^2P_{3/2} - 2\,^2P_{1/2}$, of He^+ is $5{\cdot}84\ cm^{-1}$, calculate the corresponding separation for H.

4. The rotational inertia of H_2 molecule is $4{\cdot}5\times10^{-48}\ kg\,m^2$. Compute the temperature at which the average translational kinetic energy of an H_2 molecule equals the energy difference between the ground rotational state and the first excited rotational state, $h = 6{\cdot}63\times10^{-34}$Js, $k = 1{\cdot}38\times10^{-23}JK^{-1}$.

5. Describe the salient features of the Raman spectra of heteronuclear diatomic molecules. How you would explain them?

6. What are enhancement MOSFETs and depletion MOSFETs? With the help of the transfer characteristics for the depletion and enhancement type MOSFETs, briefly describe how the depletion type MOSFETs are usually ON devices that can be switched OFF with the help of an appropriate gate signal and the enhancement type MOSFETs are usually OFF devices that can be switched ON with an appropriate gate signal.

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7. Assume that it is desired to design a Hartley oscillator so that its oscillator frequency if 4 MHz. If the capacitance C is adjusted 300 PF and the desired feedback fraction is $B = 1/20$, calculate the required value of the total tank inductance, the values of L_1 and L_2 and the minimum voltage gain A_V required for the common emitter amplifier to sustain oscillations.

8. The average lifetime of an excited atomic state is of the order 10^{-9} sec. If the spectral line associated with the decay of this state is 6000 Å, estimate the width of this spectral line using the appropriate uncertainty relationship.

9. Calculate the de Broglie wavelength of an electron having kinetic energy 1000 eV. Compare this result with the wavelength of an X-ray beam having the same energy.

10. What do you understand by the Rutherford model of an atom? Are there drawbacks in this model? How is this model different from Bohr's model of an atom?

11. Given a γ-ray of the wavelength (λ), prove that the de Broglie wavelength (λ_d) associated with the corresponding photon is equal to the wavelength of the light itself.

12. What is the quark structure of Δ^{++} resonance? What are the decay modes of Δ^{++}? Which quantum number was introduced to justify the quark structure formation of Δ^{++}?

GROUP—B

Candidates to attempt **05** ***(five)*** *questions within word limit of* **300**.
Each question carries **20** *marks.*

13. Show that the reciprocal lattice of the sodium chloride structure is bcc and a reciprocal lattice vector can be written as

$$K = \frac{4\pi}{a}(n_1 \hat{x} + n_2 \hat{y} + n_3 \hat{z})$$

where a is the side of the cube and all the coefficients n_i of a reciprocal lattice vector are integers or integer $+1/2$.

14. Derive an expression for the spin-obrit interaction energy. Draw an energy level diagram for the hydrogen atom, comparing the results of Bohr, Sommerfeld and Dirac theories.

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15. In the rotational Raman spectra of HCl the displacements from the exciting line are represented by $\Delta\nu = \pm(62{\cdot}4 + 41{\cdot}6\,J)\text{cm}^{-1}$, where J is the rotational quantum number. Calculate the moment of inertia of the HCl molecule ($h = 6{\cdot}63\times10^{-34}$Js and $c = 3{\cdot}10^{8}$ m/s).

16. What is the importance of Pauli matrices? Write down the algebraic relationship among three Pauli matrices σ_i (i=1, 2, 3) and prove that they satisfy (for i, j, k = 1, 2, 3)

$$\sigma_i\sigma_j = \delta_{ij} + i\sum_k^3 \varepsilon_{ijk}\sigma_k$$

where δ_{ij} is the Kronecker δ-function and ε_{ijk} is the Levi-Civita tensor in 3D.

17. What is Raman Effect/scattering? How is it different from Rayleigh scattering? What are the Stokes and anti-Stokes lines? Why are they equally spaced from the Rayleigh line? Explain clearly with proper arguments.

18. What is the importance of the liquid drop model of the nucleus? Write a short note on the formation of the compound nucleus and the Ghoshal experiment.

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SPACE FOR ROUGH WORK

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